State of California
The Resources Agency
DEPARTMENT OF WATER RESOURCES
Northern District

Ground Water Quality Investigation at Spalding Tract - Lassen County, California

DRAFT REPORT

OCTOBER 1990

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PREFACE

Possible ground water contamination from septic system leachfields at Spalding Tract, along the west shore of Eagle Lake in Lassen County, has been the subject of numerous studies. Prohibition of discharge of waste to individual septic systems has been ordered by the Regional Water Quality Control Board, Lahontan Region, to prevent contamination of ground water and nutrient enrichment of Eagle Lake. Some property owners at Spalding Tract oppose the prohibition and requirement to install a sewer system, while others support these actions. Residents have presented evidence and testimony that contradicts the findings of the Regional Board.

The State Water Resources Control Board contracted with the Department of Water Resources and Department of Health Services to conduct an independent study of potential ground water contamination from septic system leachfields at Spalding Tract.

This draft report has been submitted to the State Water Resources Control Board in accordance with Agreement Number 8-195-250-0. The final report will be prepared after review and comment by the State Water Resources Control Board, Department of Health Services, and Division of Local Assistance of the Department of Water Resources.

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CONTENTS

TABLES

FIGURES

SUMMARY

Considerable dissention has occurred concerning the possibility of ground water contamination by septic system effluent at Spalding Tract, which is adjacent to the western shore of the middle basin of Eagle Lake in Lassen County. Some studies have found chloride, nitrate nitrogen, and ortho-phosphate phosphorus at concentrations that are greater in downgradient wells than in an upgradient well, leading to the conclusion of widespread leachate contamination of ground water. Numerous wells have also been found to contain bacterial contamination. Other studies have found no widespread elevated concentrations of chemicals in downgradient wells, but have identified some localized increases. While the elevated chemical parameters and bacterial contamination have been attributed to septic system effluent, other possible sources have been suggested, including natural mineralization of ground water from soils and poorly constructed or sealed wells.

The State Water Resources Control Board contracted with the Department of Water Resources and Department of Health Services to conduct an independent evaluation of the ground water at Spalding Tract to determine potential contamination from septic tank effluent. The Department of Water Resources reviewed previous studies, and designed and conducted the water quality evaluation. The Department of Health Services was responsible for chemical and bacterial laboratory analyses of the ground water samples.

Chemical data collected since 1982 from wells at Spalding Tract do not indicate pervasive ground water contamination from septic system effluent. Well monitoring does not indicate increasing concentrations of minerals in ground water. Numerous wells, though, have exhibited water quality degradation, which may be due to poor construction, poor maintenance, proximity to leachfields, locally unsuitable soil conditions for underground waste systems, or shallow ground water. Generally insignificant increases in mineralization found in well water indicate relatively little effect from leachfield effluent on ground water quality. However, samples obtained from wells represent water from deep within the aquifer where dilution and insufficient vertical mixing of leachfield effluent may prevent the distinguishing of increased mineralization.

Soil adsorption capacity for present waste loads may be sufficient to prevent widespread ground water degradation, but adsorption capacity has not been determined nor the capacity for increased waste loads from increased occupancy or unrestricted future development. Clay beneath the shallow soils may be more important in preventing percolation of leachfield effluent to ground water than soil adsorption capacity. Denitrification at the clay boundary could reduce the amount of nitrate reaching ground water. Large areas of the subdivision, however, lack a clay layer separating the shallow soil layer from water-bearing basalt. These areas may be readily contaminated from leachfield effluent inadequately treated in the shallow soil layer.

Bacterial contamination in wells is rather widespread, indicating a serious potential for health problems. Bacteria species identified from several wells indicate a variety of possible sources, including humans, other animals, soil, plants, and water. All species identified, however, occur in septic system leachate. Bacterial contamination may enter wells through poorly sealed well casings, loose fitting casing caps, well caps located below grade, and percolating septic system leachate. Contamination of wells is so common that concern exists, if not for septic system leachfield contamination, then for poor well construction throughout the subdivision.

Chemical and bacteria data collected since 1982 at Spalding Tract provide circumstantial but not conclusive evidence for contamination of ground water by septic system leachfields. Other sources of contamination may also occur.

Information on adsorption capacity of the shallow soil, clay separating the soil and water-bearing basalt, and mixing of effluent into the ground water would provide better definition of the potential or extent of ground water contamination by septic system leachfields.

INTRODUCTION

The Regional Water Quality Control Board, Lahontan Region (Regional Board) has conducted water quality investigations to determine effects from septic tank effluent on ground water at Eagle Lake in Lassen County. The Regional Board has concluded that septic tank effluent is contaminating ground water used for domestic drinking water in the Spalding Tract and Stones-Bengard subdivisions.

On September 14, 1984, the Regional Board adopted Resolution Number 84-10, which amended the Water Quality Control Plan for the Eagle Lake Hydrologic Unit. The resolution prohibited new discharges of waste (septic tanks and leachfields) within the Spalding Tract and Stones-Bengard subdivisions after July 18, 1985. An exception was allowed, subject to approval from the Regional Board's Executive Officer, for installation of up to 106 units. The resolution also prohibited the discharge of waste from the Spalding Tract or Stones-Bengard subdivisions with other than a zero discharge of nutrients to any surface water or ground water in the Eagle Lake basin after September 14, 1989. The State Water Resources Control Board (State Board) approved the prohibition in July 1985.

The Regional Board adopted Resolution Number 85-16 on August 9, 1985, finding that a significant public health problem exists in the Spalding Tract and Stones-Bengard subdivisions due to contamination of drinking water supply wells from continued use of subsurface disposal systems.

A group of property owners in the Eagle Lake basin petitioned the Regional Board to rescind or amend the prohibition on discharges of waste. At a public hearing at Eagle Lake on July 19, 1987, the Regional Board instead adopted Resolution Number 87-14 which reaffirmed adoption of Resolution Number 84-10. The property owners subsequently petitioned the State Board to review Resolution Number 87-14, and rescind the prohibition of discharge. On March 21, 1988, the State Board notified the petitioners that the Regional Board resolution would not be reviewed. However, the Regional Board adopted Resolution Number 6-89-177 on August 10, 1989, postponing until September 14, 1990 enforcement of the prohibition on waste discharges.

Considerable dissention continues concerning the effects of septic tank effluent on ground water quality at Eagle Lake. Some local property owners have developed evidence purporting to show no degradation of the ground water. A University of Reno graduate student, who collected ground water quality data from July 1987 to June 1988 at Spalding Tract, concluded that the impact of septic tank effluent on ground water quality is probably very slight.

The State Board, therefore, committed to an independent study for the purpose of producing conclusive evidence regarding potential ground water contamination from septic tank effluent sources at Spalding Tract. The Department of Water Resources and Department of Health Services agreed to conduct the independent study. The Department of Water Resources was responsible for reviewing previous data, preparing a ground water sampling grid, measuring water levels, and collecting ground water samples. The Department of Health Services was responsible for analyzing the samples. Both agencies were responsible for evaluating laboratory results and determining the effects of septic tank effluent on ground water quality.

STUDY AREA

Eagle Lake is about 15 miles northwest of Susanville in Lassen County (Figure 1). Four subdivisions are located along the shore of the lake: Spalding Tract, Stones-Bengard, Buck's Bay, and Eagle's Nest. Most of the homes in the subdivisions are currently occupied only seasonally. Most homes rely on individual wells for domestic water. Disposal of domestic wastes is through individual septic systems.

Spalding Tract is on the western shore of the middle basin of Eagle Lake, within about a half mile of Pine Creek. Spalding Tract encompasses 413 acres. The subdivision has a potential of between 984 to 1,398 building sites. About 543 dwellings were present as of 1983, of which about 475 are considered seasonal and 68 are considered permanent residences (RWQCB 1984). Average lot size ranges from 12,000 to 18,000 square feet. Prior to the late 1960's, installations of septic systems were not regulated by permit. Buried 25 or 55 gallon metal barrels were sometimes installed and some are still used for receiving septic wastes.

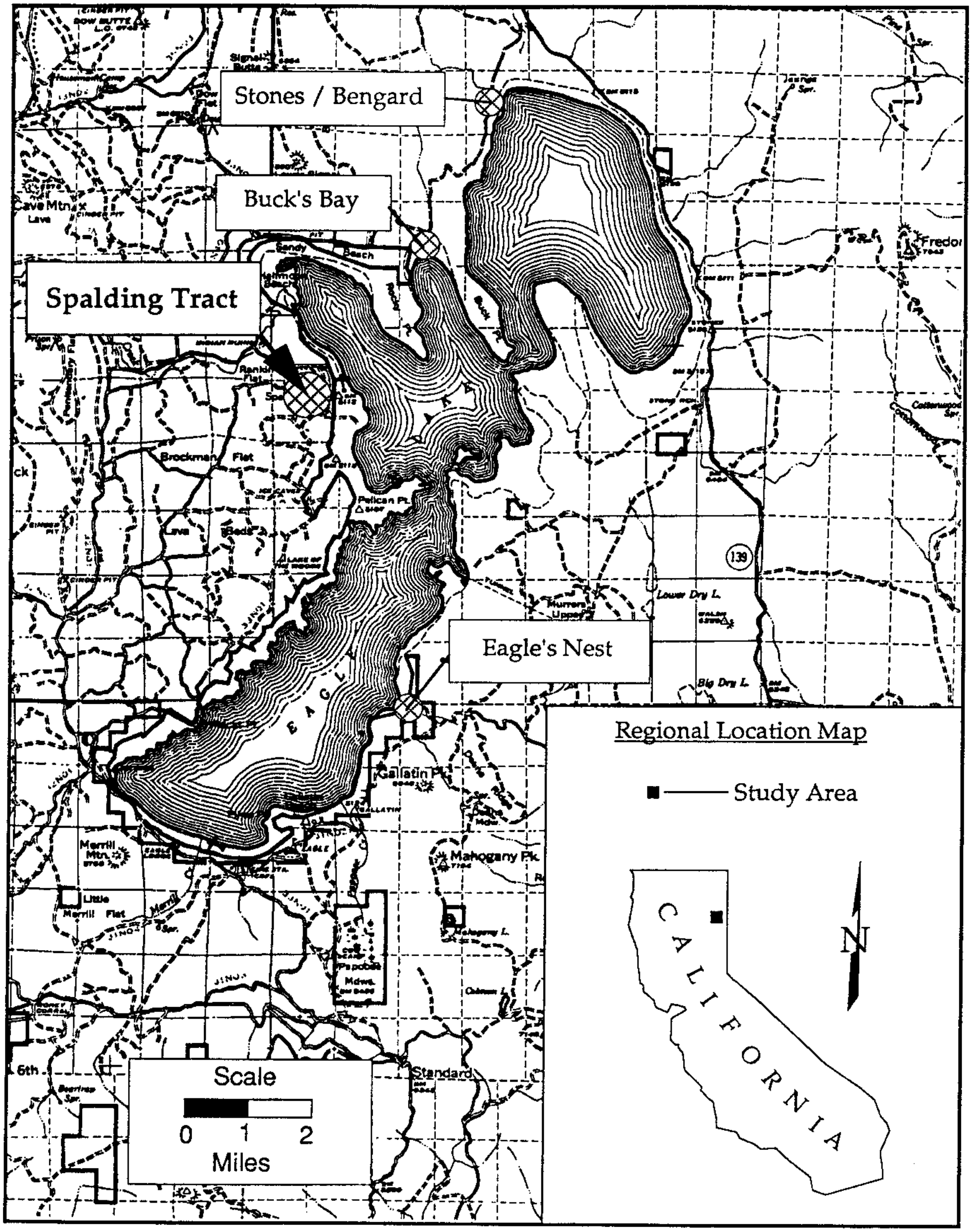


Figure 1. Spalding Tract study area.

REVIEW OF DATA

Previous data and analyses prepared by the Regional Board and the University of Nevada were reviewed and are summarized in this section. Comments on these previous investigations are indicated in italics.

Report on the Water Quality Status of Eagle Lake ...

In April of 1981, the Regional Board completed the "Report on the Water Quality Status of Eagle Lake with Consideration of Possible Eutrophication Changes." The closed basin, geologic characteristics, and anoxic south basin hypolimnion were cited as conditions that may cause Eagle Lake to be highly sensitive to eutrophication changes. Analyses of the relationships of hydrologic and nutrient budgets to present water quality were based on information previously collected by the Department of Water Resources, California State University at Chico, U.S. Forest Service, and Raymond Vail & Associates.

Phosphorus is most often the nutrient limiting algal growth in Eagle Lake. Calculations, therefore, were made for loadings of phosphorus, as well as nitrogen, from development in the basin. Numerous assumptions were made in estimating nutrient loadings: 73 year-round and 425 seasonal dwellings in the basin; average buildout of 35% for Spalding Tract and Stones-Bengard, and 100% for Eagle's Nest subdivisions; buildout of existing subdivisions would result in 209 year-round and 1,136 seasonal residences; new development would add 794 to 1,588 housing units based on 80% open space and 2 to 4 units per acre; occupancy rate of 2.98 persons per household; occupancy of seasonal units of 30 days per year; average wastewater flows of 280 liters/person/day for year-round residences and 190 liters/person/day for seasonal residences; 40 mg/L of total nitrogen and 8 mg/L of total phosphorus for average raw wastewater; combined removal efficiency of the septic tank-leachfield system of 5 to 25% for nitrogen and 0 to 90% for phosphorus; erosional yield of suspended sediment of 1.0 metric-ton/ha; nutrient loadings of 0.0063 tons of total nitrogen and 0.0099 tons of total phosphorus per ton of suspended sediment; 974 acres of potential urbanized land; 18 inches/year average precipitation; 25% runoff from precipitation; and 2.0 mg/L total nitrogen and 1.0 mg/L total

phosphorus in urban runoff. Surface and ground water flows, precipitation, and evaporation were also estimated (Figure 2). An estimated average annual nutrient budget for Eagle Lake (Figure 3) was developed from estimates and limited measurements within the basin and extrapolation of data from other areas. *Internal nutrient regeneration from the south basin during anoxic conditions in the summer was not included in the nutrient budget, nor were losses due to ground water outflow. The Regional Board estimated nitrogen and phosphorus loadings to Eagle Lake for various development scenarios (Table 1), and concluded that the actual nutrient loadings probably lie toward the upper estimates due to the poor removal efficiencies of volcanic soils and underlying fractured basalts in the basin. The ability of the lake sediments to limit the availability of additional nutrients to algae is unknown. Since these nutrient loadings are only rough estimates, additional studies were recommended to determine more precisely the effectiveness of current septic tank-leachfield systems and effluent effects on Eagle Lake.*

Table 1. Estimated nutrient loadings from various sources in the Eagle Lake Basin.

	Total Nitrogen		Total Phosphorus	
	tons/yr	% of Total	tons/yr	% of Total
Existing Subdivisions				
15% year-round	0.97-1.23	1.0-2.4	0.03-0.26	0.3-3.9
100% year-round	5.00-6.34	5.2-12.4	0.13-1.33	1.7-19.8
Buildout of Existing Subdivisions				
15% year-round	3.38-4.28	3.5-8.4	0.09-0.91	1.2-13.6
100% year-round	13.52-17.12	13.9-33.5	0.36-3.60	4.7-53.7
New Subdivisions				
15% year-round of 794 units	1.57-2.00	1.6-3.9	0.04-0.42	0.5-6.3
15% year-round of 1,588 units	3.14-4.00	3.3-7.9	0.08-0.84	1.0-12.5
100% year-round of 794 units	7.98-10.11	8.3-19.8	0.21-2.13	2.7-31.8
100% year-round of 1,588 units	15.96-20.22	16.5-39.7	0.42-4.26	5.5-63.6
Erosional Runoff				
Spalding Tract	1.16	1.2-2.3	1.68	21.9-25.1
Stones Subdivision	0.59	0.6-1.2	0.93	12.1-13.9
Bengard Subdivision	0.08	0.08-0.16	0.12	1.6-1.8
Eagle's Nest Subdivision	0.04	0.04-1.8	0.06	0.8-0.9
New Subdivisions	1.30	1.4-2.5	2.05	26.9-30.
Urban Runoff				
Existing & New Subdivisions	1.0	1.0-2.0	0.5	6.5-7.5

The purpose of this report was to describe the relationships of the hydrologic and nutrient budgets to the present water quality in the Eagle Lake basin. Numerous

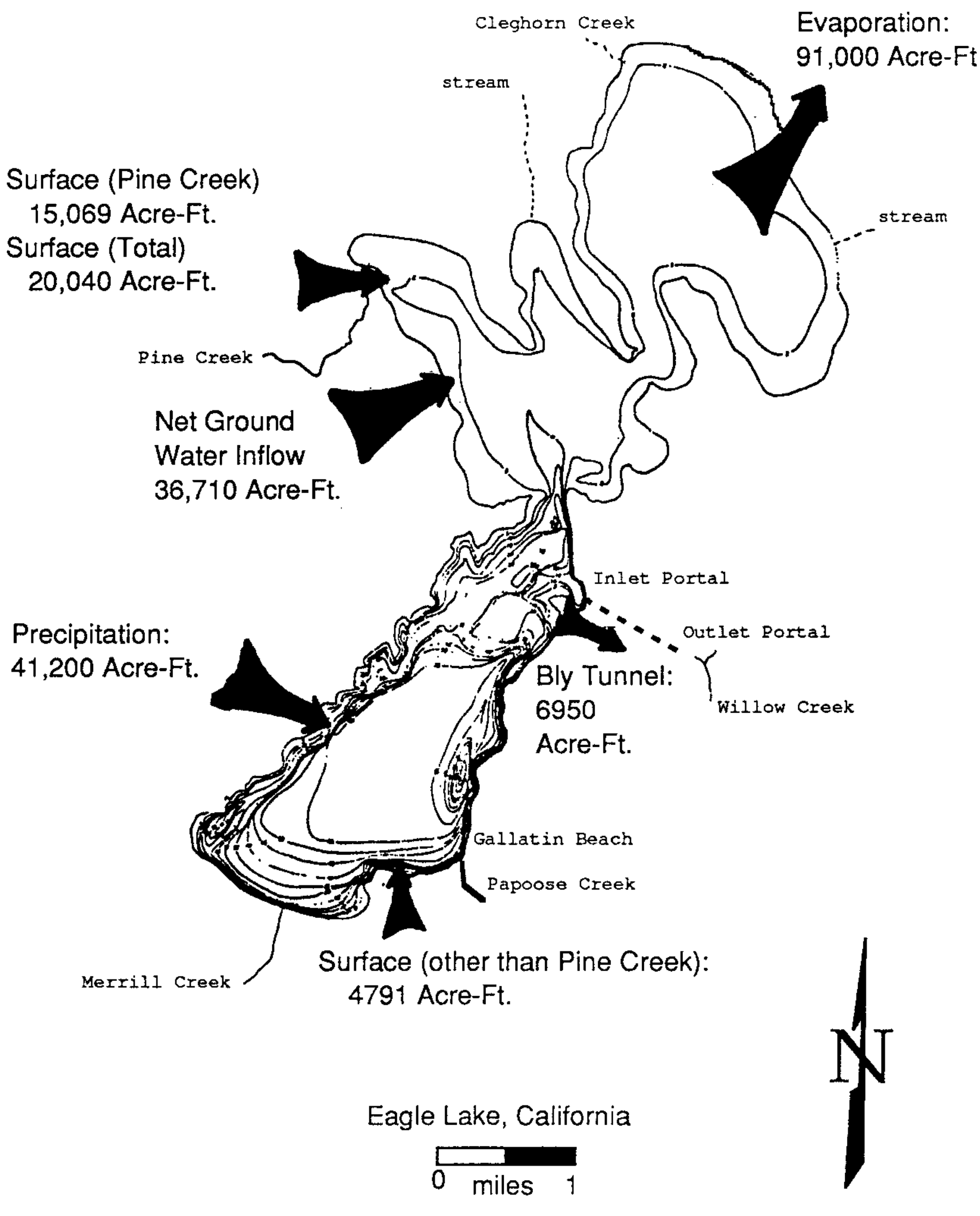


Figure 2. Estimated average annual hydrologic budget for Eagle Lake -97,950 acre-feet (from RWQCB 1981a).

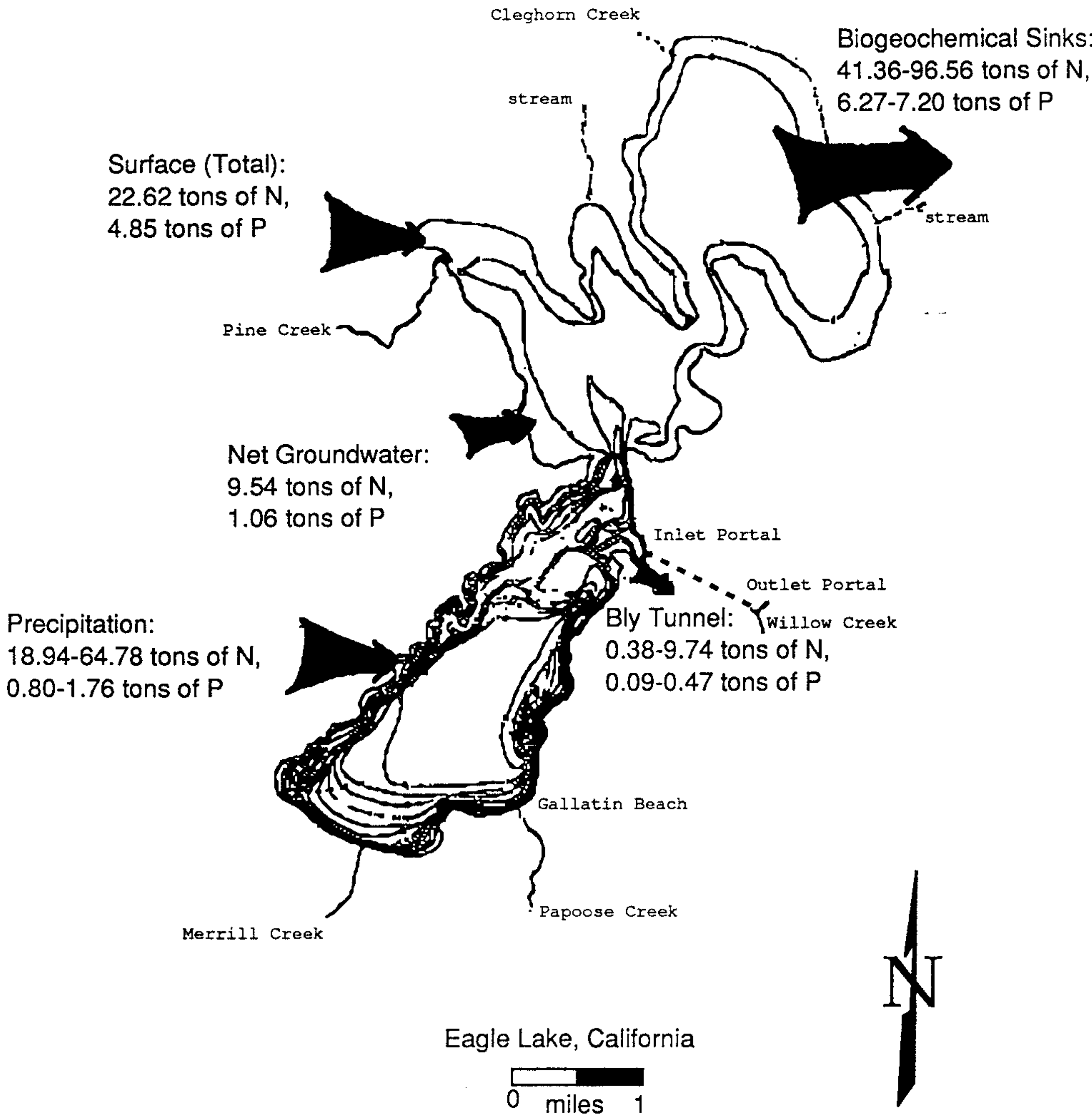


Figure 3. Estimated average annual nutrient budget for Eagle Lake (from RWQCB 1981a).

assumptions and estimates were used to develop data for analyses. Many of the data developed were admittedly imprecise due to lack of site specific information. However, the information presented is useful for determining relative magnitudes of nutrient inputs. The report is useful for determining additional information required to assess water quality conditions in the Eagle Lake basin.

Soil Profile Evaluation of the Spalding Tract ...

In May of 1981, the Regional Board prepared a supplement to the April 1981 report titled "Appendix A. Soil Profile Evaluation of the Spalding Tract, Eagle Lake Basin, Lassen County, California." For this soil profile evaluation, the Regional Board plotted nine cross sections or profiles using DWR Water Well Drillers Reports. These plots show three basic types of strata: soil, clay and basalt. The soil layer was found to be thin throughout the area, averaging 5 to 7 feet. Underlying the soil is a clay layer which averages 10 to 15 feet in depth below the ground surface, but ranges from 0 to 30 feet. Highly fractured basalt underlies the soil or clay at depths ranging from 2 to 20 feet. These representative layers were to be used for determining which sewage disposal system would be suitable for a specific site.

The minimum criteria for use of individual waste disposal systems established in the North Lahontan Basin Plan (RWQCB 1975) are: 1) the percolation rate in the disposal area shall not be greater than 60 minutes per inch; 2) clay, bedrock, or other impermeable material shall not be less than 5 feet below the bottom of the leaching trench; 3) depth to ground water below the bottom of the leaching trench shall not be less than 5 feet; 4) natural ground slope in the disposal area shall not be greater than 30 percent; and 5) the minimum distance to a domestic well from a septic tank is 50 feet and from a leaching field is 100 feet. Using the minimum requirements for siting sewage disposal systems, Regional Board staff determined that the majority of the Spalding Tract failed to meet necessary requirements. The combination of a thin soil layer overlying impervious clay or shallow fractured basalt severely restricts the suitability of the area for individual disposal systems.

These requirements for siting waste disposal systems follow recommendations of the Uniform Plumbing Code (IAPMO 1985). The Uniform Plumbing Code is based

on broad experience. Data are not available to indicate whether soils at Spalding Tract have any unusual absorption capacities that would affect siting waste disposal systems. However, data generated from the soil profiles indicate potential problems with soil availability. Shallow soil depth, clay layers, and fractured bedrock relatively near the surface pose potential problems with effective operation of subsurface waste disposal systems.

The objective of the soil profile evaluation was to establish a representative overview of the soil materials underlying the Spalding Tract. As such, the profile evaluation is a useful tool for characterizing the general suitability of the soil and underlying rocks for sewage disposal systems. However, Water Well Drillers Reports for developing soil profile information should be used cautiously due to interpretive variation among drillers. Individual well drillers may, for instance, characterize the same stratum as weathered bedrock or as clay. Therefore, interpretation of rock versus clay versus soil may not be entirely precise, and zonation between the three basic types of strata may vary considerably throughout the tract using several drillers interpretations. Also, as discussed in the staff report, the type of clay present will affect the ability of an area to meet the minimum criteria for waste disposal systems. Clay-loam substrates may meet the criteria, while impervious clay would create a drainage problem. Strata identified as "clay" by well drillers, therefore, may actually be suitable for individual waste disposal systems.

The basalt underlying Spalding Tract is of Recent age, and has been described as having a rough, vertically jointed, irregular surface which readily permits the downward percolation of precipitation (RVA 1979). This basalt is generally extremely permeable and transmits and stores large quantities of ground water. Such formations typically provide copious quantities of water to springs, streams, and lakes. The soil overlying the basalt was described as intermediate alluvium of Recent age, which generally consists of unconsolidated sand and silt with some lenses of gravel and clay. Intermediate alluvium is generally only moderately permeable, but lenses of coarse material are capable of providing sufficient quantities of water to shallow irrigation wells. Characteristics of the clay layer were not described by RVA (1979), nor did well driller logs provide sufficient information for the Regional Board to describe the clay layer.

Interpretation of the ... Eagle Lake High Water Line

The North Lahontan Basin Plan requires a minimum separation of 200 feet from a leachfield to the high water line of a lake or reservoir. The Uniform Plumbing Code of 1979, which was adopted by Lassen County, requires the same separation. The historic high water line at Eagle Lake of 5,125.2 feet above mean sea level occurred in 1917. Past diversions and current leakage through the Bly Tunnel, *which was completed in 1923*, have resulted in lake levels that fluctuate from year to year and that are less than this historic high level. Determination of the high water line that can be expected at Eagle Lake with the current status of the tunnel is necessary for regulating the placement of septic tank-leachfield systems. Regional Board staff prepared the report "Interpretation of the North Lahontan Basin Plan Regarding Eagle Lake High Water Line" in March 1982 to define the high water line.

The Department of Water Resources published the report "Eagle Lake, Alternative Plans for Controlling Lake Levels" in 1972, which predicted an October 1st maximum lake elevation of 5,116 feet based on hydrologic records for the preceding 96 year period and current tunnel leakage. Spring inflow to the lake results in an average increase in elevation of 1.5 feet, resulting in a maximum high water line of 5,117.5 feet. Regional Board staff concurred with the Department's conclusion after confirming in 1981 that earth moving activities at the tunnel entrance had not altered leakage.

The high water line was used to determine lots at Eagle Lake that would require careful evaluation of hydrologic suitability for subsurface disposal systems. The minimum surface elevation at which such disposal systems could be used was determined by adding the high water line (5,117.5 ft), depth of the standard leach line trench (3 ft), minimum depth of soil from the bottom of the trench to ground water required by the Lahontan Basin Plan (5 ft), ground water gradient determined from well logs (4.5 ft vertical change/1,000 ft horizontal distance), and a safety factor (1 ft). The Regional Board concluded that the minimum surface elevation for use of subsurface disposal systems is 5,130 feet, which would affect lots as far as 780 feet from the lake. Based on a preliminary survey of the 5,130 foot contour at Spalding Tract, 264 building sites near the lake shore of the 1,398 total building sites may be

affected. The actual number of sites affected would depend on the actual ground water level relative to the lake, the surface elevation, and proposed location of the leaching field for each particular lot.

The Porter-Cologne Water Quality Control Act requires the Regional Board to consider whether waste from individual disposal systems will impair beneficial uses of water, cause pollution, nuisance, or contamination, or unreasonably degrade the quality of water. Installation of subsurface disposal systems at elevations subject to periodic inundation would result in discharge of wastewater in violation of the Act. Periodic inundation of lots would also result in commingling of water from septic tank-leachfield systems with that from wells used for drinking water, resulting in a public health threat.

Regional Board staff recommended adoption of the 5,117.5 foot elevation as the high water mark for Eagle Lake. Staff also recommended that the 5,130 foot elevation be used as the minimum elevation for subsurface disposal systems. Lots below this elevation would require submission of data for approval of new systems and continued operation of existing systems.

The Uniform Plumbing Code (IAPMO 1985) requires a minimum leach line trench depth of 2 feet (1 foot of filter material beneath leach lines and a minimum of 1 foot of earth cover). No provisions for a safety factor are included. The "standard" leach line trench depth and safety factor requirements are stricter than those in the Uniform Plumbing Code, resulting in the recommendation of a minimum surface elevation for use of a subsurface disposal system that is 2 feet higher than required by the code.

The assumed difference between ground water and lake elevation (3.5 ft) at a distance of 780 feet from the lake was used to determine the minimum surface elevation (5,130 ft) for use of subsurface disposal systems. A preliminary location of the minimum surface elevation contour was plotted on parcel maps to determine which lots would be affected. However, sites closer to the lake, with surface elevations less than 5,130 feet, would have less increase in ground water elevation, based on a gradient of 4.5 feet per 1,000 feet horizontal distance. Such sites could,

therefore, have sufficient separation between leach trench and ground water surface to allow use of subsurface disposal systems. Regional Board staff noted that actual lot suitability must be determined based on the actual ground water level relative to the lake, surface elevation, and proposed location of the leaching field for each particular lot in question. This approach would prevent unnecessary restriction due to arbitrary adoption of a particular elevation below which development could not occur, at least until such time that accurate ground water gradients and surface elevation contours are determined.

The ground water gradient in Spalding Tract was determined using well logs. Although water levels on drillers well reports are probably the most economically obtainable data on ground water levels, use of these data for determining direction of ground water flow should be carefully qualified. Water levels in wells drilled at different times of the year, or in different years, will reflect seasonal and annual ground water level fluctuations. Also, some wells in the Spalding Tract appear to have been drilled into a zone of pressure, which means there may be a free water table and a deeper confined or semi-confined aquifer. Contouring these seasonal or separate aquifer conditions together would yield erroneous results.

Resolution 82-6

The Regional Board adopted Resolution 82-6, "Interpretation of the Water Quality Control Plan for the North Lahontan Basin Regarding Eagle Lake High Water Line", on May 13, 1982. This resolution defined the high water line of Eagle Lake to be 5,117.5 feet, given the current status of the Bly Tunnel and seal.

The resolution also prohibited the discharge of waste, unless occurring prior to May 13, 1982, from any subsurface disposal system located on any lot or portion of a lot in the Eagle Lake Basin with a surface elevation of less than 5,130 feet or that was indicated as below the 5,130 foot elevation in the March 1982 staff report. Provisions were included for exemptions upon suitable presentation to the Regional Board and County Sanitarian of geologic and hydrologic evidence that subsurface disposal will not result in pollution or nuisance.

Staff Report on Proposed Amendments to the Water Quality Control Plan ...

The "Staff Report on Proposed Amendments to the Water Quality Control Plan for the North Lahontan Basin for the Eagle Lake Hydrologic Unit" was completed by the Regional Board in August, 1984. The report discusses results from a monitoring program conducted in 1982 and 1983 designed to provide more accurate information at Eagle Lake on hydrologic and nutrient budgets, fate of nutrients in the lake, and potential nutrient loading from human usage of the basin.

Net ground water flow to Eagle Lake was assumed in the 1981 staff report based on hydrogeological expectation and analysis of about 225 well logs from Spalding Tract. Total dissolved solids, specific conductance, and pH data from ten wells in the basin (Table 2) that more closely resembled values obtained from Pine Creek than Eagle Lake were used to further support the assumed direction of ground water flow.

Table 2. Comparison of total dissolved solids (TDS), specific conductance, and pH in ground water, Pine Creek, and Eagle Lake - 1982 (from RWQCB 1984a).

Location	Well	TDS (ppm)	Specific conductance (µmhos/cm)	pH
Spalding Tract	Herrbach	136	185	7.8
Spalding Tract	Lakeview Inn	147	209	7.9
Spalding Tract	Rice	180	262	7.8
Stones No. 1	Kirsch	110	130	7.9
Stones No. 1	Christiansen	178	235	7.9
Stones No. 4	Taylor	138	154	7.9
Stones No. 4	Stone	178	235	7.9
Bald Hills C.G.	BLM	125	170	7.4
Eagle C.G.	USFS	117	200	7.5
Merril C.G.	USFS	146	210	7.4
Pine Creek	-	46-95	49-101	6.6-7.9
Eagle Lake	-	473-673	620-1004	8.7-9.2

The merits of using well logs to assess the direction of ground water flow were discussed previously. The total dissolved solids, specific conductance, and pH data do not reliably establish that ground water flow is to the lake. The elevated values in the wells, as compared to those for Pine Creek, could have resulted from dilution of lake water moving inland as likely as ground water increasing in concentration while moving through Spalding Tract to the lake. However, comparison of lake

nitrate nitrogen levels with those from Spalding Tract (DWR 1974) indicate that lake water is not responsible for the higher TDS and specific conductance of near shore wells. Nitrate nitrogen in Eagle Lake ranges up to 0.03 mg/L, while the highest recorded level in near shore wells at Spalding Tract was 5.9 mg/L, and 0.82 mg/L further inland (RWQCB 1986). Inland movement of lake water would result in dilution of the nitrate nitrogen concentration in near shore wells as compared to upgradient wells, rather than the large increase that was found. Therefore, except possibly due to localized heavy near shore ground water pumping, ground water flow appears to be toward the lake.

Wells were monitored in Spalding Tract for chloride, phosphorus as dissolved ortho-phosphate, and nitrogen as nitrate. Chloride exists as an anionic elemental species in water which passes readily through soils without removal, and as a major component of sewage effluent can be used to determine migration of wastewater. *The Department of Health Services recommends a secondary drinking water standard for chloride ion of 250 mg/L (DHS 1989).* Ortho-phosphate phosphorus is a common constituent in domestic wastewater, but is readily removed by adsorption and absorption by soils. Phosphates, therefore, are rarely used as indicators of ground water contamination. *No drinking water standards have been established,* but a water quality objective for Eagle Lake of 0.01 mg/L has been established since ortho-phosphate phosphorus is the most important nutrient required for algal growth. Ortho-phosphate phosphorus was monitored to determine whether domestic wastewater was moving untreated beneath the subdivision through fractures in the underlying basalt. Nearly all nitrogen in domestic wastewater is converted in ground water to nitrate nitrogen, which readily moves through saturated soil. High nitrate concentrations have been linked to disease in humans. *The primary drinking water objective for nitrate nitrogen is 10 mg/L. Nitrogen is the second most important limiting nutrient in the lake (Maslin and Boles 1978).*

Three wells (Frey, Lakeview Inn, and Rice) monitored along the lakeshore (Figure 4) were considered to be downgradient from leachfield systems in the subdivision. Data were presented for one well (Herrbach) considered to be upgradient from any leachfield system. Several additional wells in the western portion of Spalding Tract were sampled intermittently, but data were not presented. Results from this

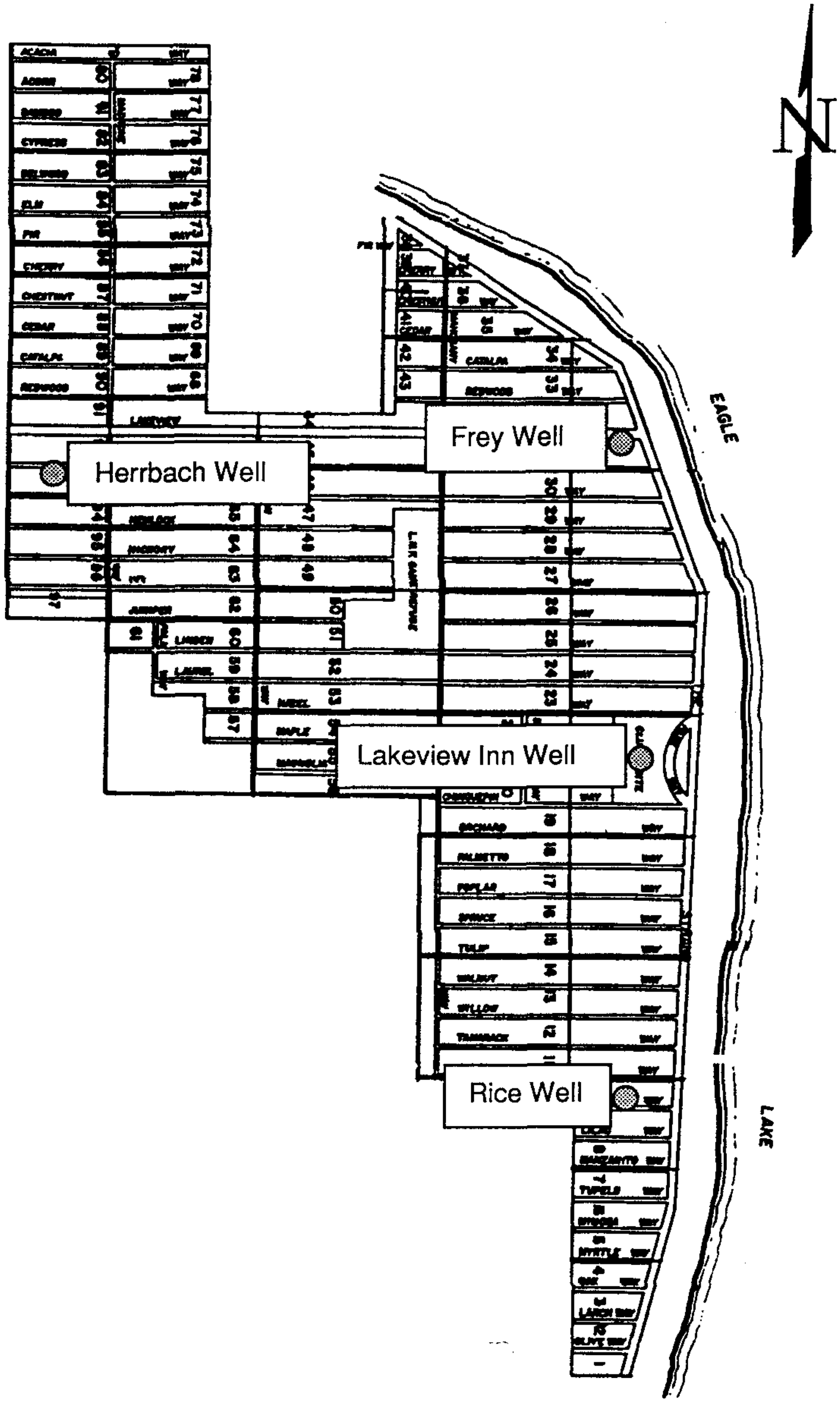


Figure 4. Upgradient and downgradient monitoring wells at Spalding Tract

intermittent monitoring were reported to be very similar to those obtained from the Herrbach well. Leachfield influences on ground water quality were determined by comparison of the mean of the monthly upgradient well concentrations and the mean downgradient well concentration calculated from the mean of the monthly concentrations from each well.

Well logs are required by law to be filed by well drillers with the Department of Water Resources. The Department maintains a numbering system for all wells for which logs have been filed. The well numbering system is preferable to use of owner names, since ownership can change or one person can own more than one well, making references to wells confusing.

The four wells used in the water quality sampling program may represent worst case quality conditions from a well construction point of view. All four have "natural earth seals", as stated by the drillers, and are only cased the length of the seal. Three are cased into basalt, and the fourth into clay. In a strict sense, these wells have no sanitary surface seal to prevent shallow zone contaminants from entering the well, whether from surface runoff or from septic system leachfields. They can also serve as conduits to allow poor quality water in the upper zones to mix with deeper water. Only the Frey well has all three soil strata identified by the soil profile analysis; the remaining three have a thin soil layer overlying basalt.

All four wells are very close to the average well depth (65 feet) throughout the subdivision, and, because of their construction, only allow analysis of composite (shallow and intermediate depth) water. From these data and analyses, it is not known whether separate water quality zones exist or whether poor well construction is playing a major role in affecting ground water quality. Ground water in the tract may all be composite given the soil permeability and the fractured nature of the basalt, but only by sampling wells completed in specific discrete zones can the subsurface conditions be reasonably characterized.

The mean chloride concentration increased 1.1 mg/L between the upgradient (0.8 mg/L) and downgradient (1.9 mg/L) wells (Table 3). Leachfield effluent was cited as generally having a chloride concentration of 50.0 mg/L plus background (0.8 mg/L),

Table 3. Chloride (mg/L) analyses from wells at Spalding Tract during the 1983 water year.

Date	Herrbach	Downgradient Frey	Lakeview Inn	Rice	Well Means
10/14/82	1	-	1	2	1.5
11/17/82	1	-	-	2	2.0
12/08/82	1	-	1	3	2.0
02/03/83	1	-	1	2	1.5
02/24/83	1	-	2	3	2.5
04/06/83	0.6	2.5	1.2	2.9	2.2
05/05/83	0.5	2.5	1.8	2.2	2.2
06/17/83	0.6	2.5	1.8	2.3	2.2
08/29/83	0.6	0.6	0.6	1.4	0.9
09/29/83	0.9	2	2.7	2.3	2.3
Mean	0.8	2	1.5	2.3	1.9

resulting in an assumed sewage contribution of chloride to the ground water of 50.8 mg/L. Since chloride is not removed in the soil, the observed chloride increase of 1.1 mg/L rather than 50.8 mg/L was attributed to reduction from diffusion and well mixing. A reduction factor of 46:1 for chloride concentration was calculated by dividing the assumed concentration of leachfield effluent (50.8 mg/L) by the observed concentration increase (1.1 mg/L). This diffusion and well mixing factor was then used to calculate the expected reduction of nitrogen and phosphorus.

Mean ortho-phosphate phosphorus concentrations increased 0.048 mg/L from the upgradient (0.048 mg/L) to downgradient (0.096 mg/L) wells (Table 4). An increase in phosphorus of 0.173 mg/L was predicted based on application of the diffusion/mixing factor to an assumed phosphorus concentration in leachfield effluent cited as 8 mg/L. The difference between the calculated and observed phosphorus increases was attributed to removal by the soil primarily through absorption and mineralization. A removal efficiency of 72.3 percent was calculated (100X(1-0.048/0.173)), which was considered typical of removal rates reported in the literature ranging from 60 to 90 percent.

Dissolved nitrate nitrogen was reported to increase by 0.82 mg/L from a mean of 0.21 mg/L in the upgradient well to a mean of 1.03 mg/L in the downgradient wells. *Using the procedures in the report, the mean nitrate nitrogen concentration in the downgradient wells is actually 1.23 (Table 5), resulting in an increase from the*

Table 4. Ortho-phosphate phosphorus (mg/L) analyses from wells at Spalding Tract during the 1983 water year.

		Downgradient			
Date	Herrbach	Frey	Lakeview Inn	Rice	Well Means
10/14/82	0.05	-	0.08	0.10	0.09
11/17/82	0.04	-	-	0.07	0.07
12/08/82	0.04	-	0.08	0.08	0.08
02/03/83	0.08	-	0.05	0.08	0.065
02/24/83	0.05	-	0.08	0.06	0.07
04/06/83	0.04	0.25	0.08	0.07	0.133
05/05/83	0.056	0.194	0.062	0.07	0.109
06/17/83	0.032	0.11	0.048	0.042	0.067
08/29/83	0.042	0.092	0.055	0.06	0.069
09/29/83	0.048	0.124	0.06	0.04	0.075
Mean	0.048	0.154	0.066	0.067	0.096

Table 5. Nitrate nitrogen (mg/L) analyses from wells at Spalding Tract during the 1983 water year.

		Downgradient			
Date	Herrbach	Frey	Lakeview Inn	Rice	Well Means
10/14/82	0.26	-	0.33	1.7	1.02
11/17/82	0.19	-	-	1.4	1.4
12/08/82	0.22	-	0.31	2.5	1.41
02/03/83	0.05	-	0.3	2.8	1.55
02/24/83	0.3	-	0.32	3.2	1.76
04/06/83	0.24	1.8	0.27	2.2	1.42
05/05/83	0.11	1.7	0.15	0.64	0.83
06/17/83	0.14	1.92	0.09	0.15	0.72
08/29/83	0.25	1.04	0.33	0.84	0.74
09/29/83	0.38	2.46	0.46	0.86	1.26
Mean	0.21	1.78	0.28	1.63	1.23

upgradient well of 1.02 mg/L. A 0.87 mg/L increase in nitrate nitrogen was predicted based on application of the diffusion/mixing factor and an assumed total nitrogen concentration cited as 40 mg/L in leachfield effluent, with all nitrogen assumed to be in the form of nitrate. The report states "the fact that the observed increase of 1.03 mg/L (*actually 1.02 mg/L*) is greater than the 0.87 mg/L expected increase indicates that there is some inaccuracy in ground water measurement due to the small number of wells." *This discrepancy may also indicate that the septic nitrogen loading in Spalding Tract is greater than the 40 mg/L typical nitrogen loading or the diffusion/mixing factor is not appropriate. A significant decrease in nitrate nitrogen concentrations in the Rice Well occurred beginning with samples*

collected May 5, 1983. Prior to this date, nitrate nitrogen averaged 2.3 mg/L. Since May 5, nitrate nitrogen averaged only 0.62 mg/L.

Additional wells are needed to demonstrate that the measured increases in chloride, ortho-phosphate phosphorus, and nitrate nitrogen in the wells near the lake are the result of accumulation from septic systems as the ground water moves through Spalding Tract, rather than from other causes. These materials would be expected to increase in concentration as the ground water moves through the soils near Eagle Lake, whether the subdivision were present or not. The soils likely contain relatively high concentrations of minerals deposited as Eagle Lake receded from high levels during the Lake Lahonton period. White alkali incrustations deposited during much higher lake levels are reported at an elevation of 5,143 feet (RVA 1979), which is about 26 feet above the expected high water line.

The increases in concentration of chloride, ortho-phosphate phosphorus, and nitrate nitrogen are slight, and not what would be expected from widespread contamination of ground water with septic tank-leachfield effluent. In the Chico area in Butte County, chloride concentrations had been found to increase up to 77 mg/L with a median value of 17 mg/L (DWR 1984). In the Antelope area south of Red Bluff in Tehama County, chloride concentrations were found up to 219 mg/L with a median value of 14 mg/L (DWR 1987). Nitrate nitrogen concentrations increased to as much as 37 mg/L from a background level of about 4 mg/L in the Chico area, while concentrations in the Antelope area increased to as much as 14 mg/L with a median concentration of 3 mg/L. Both communities, however, contain significantly more septic systems than Spalding Tract. Sources other than septic systems, such as agricultural fertilizers, undoubtedly contribute some of the nitrates to the ground water in these areas, but are not likely responsible for the increased chloride concentrations. The normal functioning of septic tank-leachfield systems is expected to result in some increase of these materials in the ground water, but this would not indicate failing or inappropriately located systems.

Calculation of the mean concentration in the downgradient wells of chloride, ortho-phosphate phosphorus, or nitrate nitrogen from the mean of each well is mathematically incorrect. The mean well concentrations should be calculated from

individual (semi-monthly) measurements. The mean downgradient chloride concentration calculated from the individual measurements is not different than that cited in the report for results expressed in tenths of a milligram per liter. However, correct calculation of the mean concentrations for ortho-phosphate phosphorus (0.085 mg/L) and nitrate nitrogen (1.16 mg/L) are substantially different than those reported (0.096 and 1.23 mg/L, respectively). The actual differences between the upgradient and downgradient wells, therefore, are 0.037 mg/L for ortho-phosphate phosphorus and 0.95 mg/L for nitrate nitrogen. The removal efficiency thus becomes 78.6 percent for ortho-phosphate phosphorus, which is still within the 60 to 90 percent range cited from the literature.

Combining downgradient wells into a single value and use of mean values results in less robust comparisons than statistical analyses among paired observations (upgradient to each downgradient well). Statistical analyses for paired comparisons commonly rely on significance levels that are not greater than 5 percent (probability of 0.05) for concluding differences exist between samples (Steel and Torrie, 1960). Statistical analyses using the Student's t-test with two tail probability indicate significant differences for chloride, ortho-phosphate phosphorus, and nitrate nitrogen between the upgradient and each downgradient well (Table 6). This analysis indicates that the patterns of occurrence of monthly concentrations is different between the upgradient and each downgradient well. Though differences in patterns of occurrence of the various parameters are statistically significant, the magnitude of the differences are not mathematically significant. As discussed previously, such differences can be expected from natural sources as water moves through the ground, though input from septic systems may also contribute to differences. Statistical differences in ground water composition between upgradient and downgradient wells should also be expected due to the time of travel from the upgradient to downgradient wells. Water at the downgradient wells may have entered the ground months before that to which comparisons are being made at the upgradient well. The data from the upgradient well show that the water quality varies with time. The upgradient well, therefore, is being compared with downgradient wells whose water may have been initially different. Statistical analyses are probably more useful for determining where no differences exist between upgradient and downgradient wells, rather than to infer differences.

Table 6. Statistical comparisons using Student's t-test of upgradient (Herrbach) to downgradient wells.

Well	*Degrees of Freedom*	*Probability*[1]		
		Cl	*o-PO_4-P*	*NO_3-N*
Frey	*4*	*0.0224*	*0.0185*	*0.0019*
Lakeview	*8*	*0.0221*	*0.0424*	*0.0362*
Rice	*9*	*0.0001*	*0.0078*	*0.0018*

[1] *Differences are significant where probability is 0.05 or less.*

The Spalding Tract soils were considered very poorly suited for leachfield systems (based on soil profile observations), and therefore would have low removal rates for nitrogen. The downgradient nitrate nitrogen mean of 1.03 mg/L (*actually 1.23 mg/L*) would be expected to increase to 8.5 to 12.1 mg/L (*actually 10.1 to 14.7 mg/L*) as a result of 100 percent build-out and year-round occupancy of Spalding Tract, which is currently about 40 to 55 percent developed with about 12.6 percent year-round residents. This estimated increase assumes a proportional relationship between development and ground water nitrogen values. In determining these calculations, Regional Board staff estimated 68 permanent residences and 475 seasonal residences. Permanent residences were estimated to produce 74 gallons of sewage effluent per person per day throughout the year, while seasonal residences were estimated to produce 50 gallons per person per day during an average stay of 30 days per year. The average residence was assumed to contain 2.98 persons. Effluent was assumed to contain 40 mg of nitrate nitrogen per liter. Converting metric units to customary units, permanent residences were calculated to produce 1,825 pounds of nitrogen per year, while seasonal residences produce 707.8 pounds per year. Permanent residences are, therefore, assumed responsible for producing 72.1 percent of the total nitrogen load. Assuming proportional relationships between development and ground water nitrogen levels, permanent residences were determined to be responsible for 0.59 mg/L of the *incorrectly calculated* 0.82 mg/L increase in nitrate nitrogen from the upgradient to average downgradient concentration. *(Permanent residences should have been determined to be responsible for 0.74 mg/L of the correctly calculated 1.02 mg/L increase from the upgradient to average downgradient concentrations).* If 12.6 percent of year-round use and 55 percent build-out produces a 0.59 mg/L *(actually 0.74 mg/L)* increase in nitrate nitrogen concentration in the ground water, 100 percent year-round use and

build-out would produce an 8.5 mg/L *(actually 10.7 mg/L)* increase. An increase in build-out from 40 percent to 100 percent would result in calculation of an increase in nitrate nitrogen to 12.1 mg/L *(actually 14.7 mg/L)*. The latter calculation results in concentrations that exceed the Department of Health Services drinking water standard of 10 mg/L of nitrate nitrogen. *Little actual data and many assumptions were necessary to calculate future ground water nitrate nitrogen concentrations. The calculations did not consider hydrogeological properties, such as soil absorption capacity and dilution by ground water. Neither parameter has been quantified, leaving any determination of nitrate nitrogen loading to conjecture. However, the thin soil layer overlying impervious clay or shallow fractured basalt in much of the area indicates limited soil absorption capacity which may be easily overloaded with increased development. Ground water flow may be sufficient in some years to flush nitrate nitrogen to acceptable concentrations, but may allow development of concentrations that exceed drinking water criteria during drier years. The calculations also assume that the average downgradient well nitrate nitrogen levels actually reflect accumulation as ground water moves through Spalding Tract, rather than increased nitrate nitrogen levels from other causes, such as local geologic conditions or contamination from nearby septic tanks rather than widespread contamination.*

Soil samples were collected from 48 trenches excavated to a depth of eight feet at Spalding Tract between May 13 and June 23, 1983 for phosphorus adsorption capacity analyses. Results were not presented. *Apparently, the analyses were not conducted. Regional Board staff were unable to locate results from any analyses.*

Soil profiles in the trenches were evaluated for conformance to Basin Plan criteria for depth to bedrock and ground water. Observed soil types were also qualitatively appraised for ability to meet percolation criteria. The Basin Plan requires at least 5 feet of soil beneath a leachline trench; the trench to be at least 5 feet above the highest historic ground water level; and that soil permeability must be satisfactory. Soil mottling was used to indicate historic ground water levels. Trenches meeting all the requirements were classified as acceptable; inadequate soil depth or evidence of historic ground water levels within 8 feet of the ground surface (*5 foot separation plus 3 foot depth of leachline trench required in the basin plan*) resulted in a rating

of unacceptable; unsatisfactory appearance of soil characteristics for permeability or texture were rated as questionable.

Soil mottling was observed in trenches approximately 20 feet higher than the highest recorded lake level (*5,125.2 ft in 1917*). The historic ground water levels were considered apparently not directly attributable to previous high lake levels. *Lake levels higher than that recorded in 1917 are apparent from deposits of shells and alkali incrustations, and wave cut terraces. Well defined wave cut terraces are present as high as 53 feet (elevation 5,178 feet) above the recorded high water level (RVA 1979). Less well defined wave cut terraces occur at 63 feet above the recorded high water level. Soil mottling observed in the trenches may be due to these past lake levels rather than historic ground water levels.*

Seventy percent of the soil in Spalding Tract was classified as unsuitable for septic tank-leachfield systems. Most of the southern portion of the subdivision was found to be underlain by shallow basalt flows and, to a lesser extent, mottled soil (Figure 5). The most suitable soils, classified as questionable to acceptable, occurred only along a narrow strip subparalleling Lakeview Way and along the southwest subdivision border. Sixty-five percent of the 48 excavated trenches in Spalding Tract were rated as unacceptable, while 29 percent were questionable, and 6 percent were acceptable. Recommendations were made for investigations of individual building sites to obtain data from more than one trench due to the geological setting that results in a highly variable nature of soil, and to perform a standard soil sieve analysis for all soil types in the soil profile to determine suitability for providing adequate biological treatment.

Results of the soil evaluations based on Basin Plan criteria for depth to bedrock are fairly straight forward. Fourteen of the 48 trenches (29 percent) encountered bedrock at depths of 7.5 feet or less. However, the use of soil mottling to establish historic high ground water levels may not be appropriate. Ground water was not encountered in any of the excavated trenches. Examination of Water Well Drillers Reports shows an average depth to ground water of 35 feet, and a range of 16 to 65 feet. The remaining 34 trenches, or 71 percent of the area examined, would thus appear to be acceptable for leachfield systems. Soil mottling seems to be associated

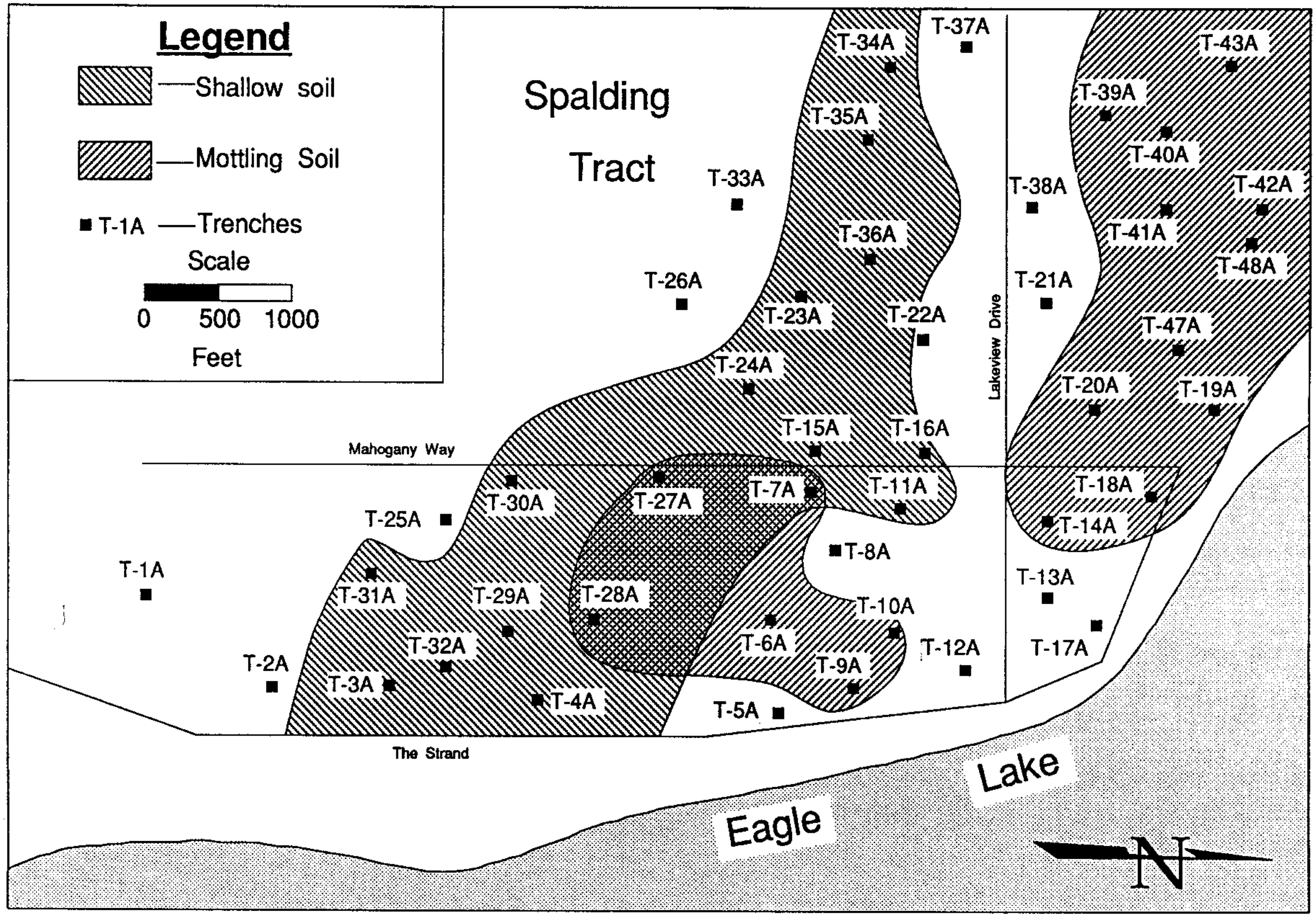


Figure 5. Soil characteristics in Spalding Tract determined from trenches.

with the distribution of clays in the subsurface and could represent a wet-year zone of perched shallow water in areas of poor drainage, which could further substantiate unacceptable permeability rates in those areas.

The areas deemed acceptable seem to have slightly deeper profiles and soils with sandier textures. Such areas would have better drainage characteristics than the clay soils. Comparing the "acceptable" trench profiles to strata in nearby wells (using the lithology on drillers reports) shows that below the sandy soil there is little difference in the strata between "acceptable" and "unacceptable" areas. The surficial differences are due to slight variations in the alluvium soil textures.

Results from the excavated trenches indicate that some lots or areas may not be suitable for septic tank-leachfield systems and that some current units may have been placed inappropriately. Site specific evaluation is apparently needed to determine suitability of underlying soils for placement of any new septic system.

Both the Herrbach and Frey wells are near Lakeview Way in areas with soils determined to be most suitable for waste disposal systems. The Lakeview Inn and Rice wells are in unacceptable areas due to mottling and shallow soil, respectively.

Regional Board staff concluded that ground waters from both the Spalding Tract and Stones-Bengard subdivisions contained sufficient nutrients to stimulate eutrophication of Eagle Lake, which would adversely affect wildlife and recreational beneficial uses. Present subsurface disposal systems were considered to possibly result in bacterial, pathogenic, and nitrate pollution of ground water used for domestic water supply. Future development was considered to very likely result in pollution of ground water in excess of drinking water standards. Prohibition of discharges of wastes within these subdivisions after September 14, 1989 was recommended due to intolerable adverse water quality impacts resulting from continued use. An increase in phosphorus loading to Eagle Lake of one percent was considered to probably not result in a significantly large increase in algal productivity. The one percent increase in phosphorus loading was estimated to result from an additional 104 year-round residences. Therefore, an exemption was proposed to allow the installation of 106 (*apparently a typographical error)* disposal

systems on an interim basis in addition to systems that were discharging by February 1, 1984.

An alternative of allowing continued discharge from existing subsurface disposal systems, while prohibiting installation of new ones, was determined to not eliminate water quality degradation. Based on year-round use of all existing systems, *which currently does not occur,* nutrient loading to Eagle Lake was considered to likely result in significant increases in algal production. While nitrate levels in ground water at Spalding Tract would probably not exceed drinking water criteria, bacteria and pathogen contamination was considered likely due to the soil and geologic conditions. Effective individual disposal alternatives were considered to be technically infeasible due to the small lot sizes in Spalding Tract, so a community collection system was deemed necessary. *An alternative to the community system not considered is a vault system to contain septic wastes. A vault system would require periodic pumping and hauling of wastes, the frequency of which depends on amount of use. Seasonal residences would require less frequent service than permanent residences. Less frequent servicing may be achieved by directing gray water (bath, laundry, etc.) to a leachfield while directing septic wastes to the vault. Retrofitting existing waste disposal systems may not be practical, but owners of undeveloped property could be allowed to develop their lands using vault systems for waste disposal.*

Resolution No. 84-10

On September 14, 1984, the Regional Board adopted Resolution No. 84-10, "Adopting Amendments to the Water Quality Control Plan for the North Lahontan Basin Concerning the Eagle Lake Hydrologic Unit." The amendments added numerical objectives for Eagle Lake and tributary waters. Numerical objectives were added for dissolved nitrate and total Kjeldahl nitrogen, dissolved ortho-phosphate and total phosphorus, chlorophyll-a, phytoplankton, and secchi disk transparency. Discharges of waste to waters of the Eagle Lake Hydrologic Unit were prohibited which would cause, among other things, an alteration in biostimulatory substances that results in an increase in aquatic biomass and algal growth potential, or change in aquatic species composition discernible at the 90 percent significance level,

concentrations of coliform organisms attributable to human wastes, or an increase in surface waters of chemical constituents, including nitrogen and phosphorus. Ground water used for domestic supply was prohibited from containing a median concentration of coliform organisms during any seven day period that was 2.2 organisms or more per 100 milliliters of water, or concentrations of chemical constituents in excess of the limits specified in the California Administrative Code, Title 22, Chapter 15, Article 4, Section 64435, Tables 2 and 4. *The California Administrative Code specifies a maximum contaminant level for nitrate of 45 mg/L (10 mg/L of nitrate nitrogen) and recommends a limit of 250 mg/L for chloride; no contaminant levels are specified for ortho-phosphate (DHS 1989).*

Implementation measures for the Spalding Tract and Stones-Bengard subdivisions to achieve the water quality objectives included prohibitions of new discharges from subsurface disposal systems after September 14, 1984, and of discharge of sewage by a system that has other than a zero discharge of nutrients to surface waters and ground waters in the Eagle Lake basin after September 14, 1989. An exemption was provided to allow 106 units to be installed on an interim basis, upon approval, in addition to units which were discharging prior to February 1, 1984. Existing subsurface disposal systems would be allowed to continue to discharge wastes until September 14, 1989.

Data collected from the two year study discussed in the 1984 report were used to justify the prohibitions. Septic tank and leachfield systems in Spalding Tract, Stones-Bengard, and Eagle's Nest subdivisions were stated to add about 3.3 percent of the total nitrogen and 1.1 percent of the total phosphorus loads to Eagle Lake. With build-out and year-round occupancy, these percentages were expected to increase to between 9.7 and 12.8 percent for phosphorus and 23.7 and 31.6 percent for nitrogen. Current loads of nitrogen and phosphorus from the subdivisions were not thought to significantly stimulate algal growth in Eagle Lake. With build-out and year-round occupancy, however, the collective nitrogen and phosphorus loads were expected to significantly stimulate algal growth, thus violating the objectives for biostimulatory substances and algal growth potential. Nutrient loads from Spalding Tract alone were felt to very likely be significant in the future. *Neither build-out nor year-round occupancy are certain. Many of the current residents own adjacent*

property purchased to provide a buffer between possible future neighbors. Other lots may not be buildable due to soil characteristics completely unsuitable for installation of septic systems or insufficient size to meet the required spacing of well and septic system. Therefore, not all of the parcels in Spalding Tract will eventually be developed. Many of the current residences are seasonal. Though additional development would result in additional year-round residences, many residents would continue to find winter conditions too severe for year-round occupancy.

The study data were also used to determine that the ground water in Spalding Tract has been deteriorated by current development, though not presently exceeding health criteria. With build-out and year-round occupancy, Regional Board staff expected the drinking water standard for nitrate nitrogen to be exceeded. Only six percent of the soils in the subdivision were considered to meet the minimum criteria for subsurface disposal systems in the 1975 Basin Plan. Bacterial contamination, though not yet observed, was felt to be a very real possibility in the near future. Exceeding the standards for nitrate nitrogen and bacterial contamination in wells supplying drinking water would be violations of the objectives.

<u>First Annual Report on the 205j Eagle Lake Index Station Productivity...</u>

The Regional Board completed the "First Annual Report on the 205j Eagle Lake Index Station Productivity and Routine Ground Water Nutrient Monitoring Program" in 1985. The report discusses data collected during the 1984 water year for primary conductivity index stations on Eagle Lake, and ground water quality monitoring from wells in subdivisions around the lake. Chloride, ortho-phosphate phosphorus, and nitrate nitrogen were sampled from the same wells as in previous studies (Tables 7 through 9). Regional Board staff conducted most of the chemical analyses. Water year mean concentrations were calculated for each parameter and well, and compared to 1983 water year data (Table 10).

Little difference occurred between water years for each parameter except nitrate nitrogen, which decreased significantly in the Rice well in the 1984 water year. The mean of the three downgradient wells was noted to remain considerably higher for

Table 7. Chloride analyses (mg/L) from wells at Spalding Tract during the 1984 water year.

		Downgradient			
Date	Herrbach	Frey	Lakeview Inn	Rice	Well Mean
10/29/83	2.70	2.20	2.20	2.00	2.13
12/04/83	1.44	1.40	0.78	3.50	1.89
12/17/83	2.63	0.72	1.94	1.44	1.37
01/22/84	0.97	3.44	-	1.81	2.63
02/10/84	0.66	-	-	0.97	0.97
02/19/84	0.78	-	-	-	-
04/01/84	0.78	3.44	-	1.02	2.23
04/24/84	0.55	-	-	1.02	1.02
05/20/84	0.55	2.10	0.73	1.85	1.56
06/30/84	0.43	0.93	0.73	0.53	0.73
07/29/84	1.00	3.11	1.35	1.75	2.07
08/24/84	0.97	2.50	1.26	1.93	1.90
09/26/84	0.92	2.09	1.23	1.69	1.67
MEAN	1.11	2.19	1.28	1.63	1.70

Table 8. Ortho-phosphate phosphorus analyses (mg/L) from wells at Spalding Tract during the 1984 water year.

		Downgradient			
Date	Herrbach	Frey	Lakeview Inn	Rice	Well Mean
10/29/83	0.06	0.10	0.08	0.08	0.09
12/04/83	0.06	0.20	0.06	0.07	0.11
12/17/83	0.06	0.11	0.06	0.04	0.07
01/22/84	0.04	0.18	-	0.04	0.11
02/10/84	0.02	-	-	0.05	0.05
02/19/84	0.05	-	-	-	-
04/01/84	0.05	0.11	-	0.06	0.09
04/24/84	0.04	-	-	0.06	0.06
05/20/84	0.07	0.09	0.09	0.09	0.09
06/30/84	0.05	0.15	0.09	0.07	0.10
07/29/84	0.04	0.12	0.06	0.06	0.08
08/24/84	0.04	0.17	0.05	0.05	0.09
09/26/84	0.06	0.17	0.07	0.06	0.10
MEAN	0.05	0.14	0.07	0.06	0.09

each parameter than the mean of the upgradient Herrbach well, which was assumed to indicate continued degradation from subsurface disposal systems. The decrease in difference between mean upgradient and downgradient well concentrations of nitrate nitrogen were felt to possibly be due to a low occupancy rate and a normal water year in 1984 following two very wet water years, which in turn were preceded by two very dry years.

Table 9. Nitrate nitrogen analyses (mg/L) from wells at Spalding Tract during the 1984 water year.

Date	Herrbach	Downgradient Frey	Lakeview Inn	Rice	Well Mean
10/29/83	0.45	1.94	0.43	0.74	1.04
12/04/83	0.14	1.65	0.14	0.42	0.74
12/17/83	0.09	0.60	0.18	0.50	0.43
01/22/84	0.23	1.54	-	0.31	0.93
02/10/84	0.82	-	-	0.56	0.56
02/19/84	0.25	-	-	-	-
04/01/84	0.16	1.92	-	0.28	1.10
04/24/84	0.16	-	-	0.31	0.31
05/20/84	0.08	1.66	0.08	0.06	0.60
06/30/84	0.25	1.64	0.26	0.35	0.75
07/29/84	0.13	1.57	0.15	0.19	0.64
08/24/84	0.10	0.96	0.85	0.17	0.66
09/26/84	0.12	1.51	0.19	0.29	0.66
MEAN	0.23	1.50	0.28	0.35	0.71

Table 10. Comparison of mean ground water quality data (in mg/L) for water years 1983 and 1984.

	Chloride		Ortho-phosphate phosphorus		Nitrate nitrogen	
	1983	1984	1983	1984	1983	1984
Herrbach	1	1.11	0.05	0.05	0.21	0.23
Frey	2	2.19	0.15	0.14	1.8	1.50
Lakeview Inn	1	1.28	0.07	0.07	0.28	0.28
Rice	2	1.63	0.07	0.06	1.6	0.35

Statistical comparisons using the two-tailed Student's t-test indicate no differences in occurrence of chloride during the 1984 water year between the upgradient (Herrbach) well and all the downgradient wells at the 5 percent significance level (Table 11). Differences in occurrence of ortho-phosphate phosphorus were statistically significant between the upgradient and each downgradient well. However, concentrations of ortho-phosphate phosphorus in both the Lakeview Inn and Rice wells were often the same, but sometimes only slightly higher, as in the Herrbach well. Nitrate nitrogen differences were statistically significant between the upgradient and downgradient Frey and Rice wells, but not the Lakeview Inn well. Nitrate nitrogen levels in the Frey well were substantially higher than those in the Herrbach well. The Lakeview Inn well had nitrate nitrogen concentrations that were very similar to those in the Herrbach well, while concentrations in the Rice well were most often higher, but not as high as in the Frey well.

Table 11. Statistical comparisons of upgradient (Herrbach) to downgradient wells for water year 1984.

Well	*Degrees of Freedom*	*Probability*[1] *Cl*	*o-PO_4-P*	*NO_3-N*
Frey	*9*	*0.0664*	*0.0001*	*0.0001*
Lakeview Inn	*7*	*0.7626*	*0.0142*	*0.2499*
Rice	*11*	*0.0722*	*0.0116*	*0.0307*

1 Differences are significant where probability is 0.05 or less.

Information is not provided for occupancy rates for the 1984 water year, nor any other water year. Therefore, the effect of occupancy rates on possible ground water contamination from individual septic tank-leachfield systems cannot be determined. Presumably, the two dry years in 1980 and 1981 allowed wastes to concentrate in the soil, which were then flushed during the wet years of 1982 and 1983, resulting in lower concentrations of nitrate nitrogen by 1984. However, such flushing action is not indicated for chloride or ortho-phosphate phosphorus. Furthermore, nitrate nitrogen concentrations in the Rice well, which decreased significantly in May of 1983 (Table 5), have remained at the greatly reduced levels through 1984. The other two downgradient wells do not display a similar pattern. The altered water quality in the Rice well does not indicate flushing due to wet water years, but may be due to mechanical alteration such as surface sealing of the well.

Staff Report on Bacterial Levels of Eagle Lake Drinking Supply Wells

Results of sampling for bacterial contamination in ground water in Spalding Tract are presented by the Regional Board in the July 1985 report "Staff Report on Bacterial Levels of Eagle Lake Drinking Supply Wells." The Regional Board sampled the four monitoring wells in Spalding Tract for bacterial contamination from May 20, 1984 to June 22, 1985. The 3 downgradient and 22 additional wells were also sampled on June 30 and July 1, 1985. The 5 tube multiple-tube fermentation technique was used for coliform bacteria analyses.

Total coliform bacteria were found in the upgradient Herrbach well and the downgradient Frey and Lakeview Inn wells during the fourteen months of

monitoring (Table 12). Bacteria were detected in the spring and early summer of 1984, but not in late summer or through the winter. During the spring of 1985, coliform bacteria were only detected in April from the Frey well. Fecal coliform analysis from the Frey well at this time produced a positive response. Subsequent analyses of all the wells on May 26 and additional analyses of the Frey well on May 31, 1985 failed to indicate bacterial contamination. *Coliform bacteria were present only at the lowest level detectable by the multiple-tube fermentation technique. Only one of the five tubes used in the multiple-tube fermentation technique indicated coliform bacteria in each positive response. The most probable number (MPN) of coliform bacteria calculated for one positive tube is 2.2 bacteria per 100 milliliters of sample, with a possible range at the 95 percent confidence limits of 0.1 to 12.6 bacteria per 100 milliliters of sample (APHA 1989). Bacterial contamination in the Herrbach well, which was considered to be upgradient of development in Spalding Tract, may indicate contamination of the samples from other sources, such as during collection, or well contamination from surface contaminants through the inadequate well seals of the Herrbach and other three monitoring wells.*

Table 12. Coliform bacteria (MPN) analyses of wells at Spalding Tract.

Well	5/20/84		6/30/84		7/29/84		8/28/84-2/2/85		3/16/85		4/29/85		5/26/85		6/22/85	
	TC	FC	TC	FC	TC	FC	TC	FC	TC	FC	TC	FC	TC	FC	TC	FC
Herrbach	2.2	NT[1]	2.2	NT	<2.2	NT	<2.2	NT	<2.2	NT	<2.2	NT	<2.2	NT	<2.2	NT
Frey	2.2	NT	2.2	NT	2.2	NT	<2.2	NT	<2.2	NT	2.2[2]	2.2[2]	<2.2	NT	<2.2	NT
Lakeview Inn	<2.2	NT	2.2	NT	2.2	NT	<2.2	NT	<2.2	NT	<2.2	NT	<2.2	NT	<2.2	NT
Rice	<2.2	NT	<2.2	NT	<2.2	NT	<2.2	NT	<2.2	NT	<2.2	NT	<2.2	NT	<2.2	NT

1 Not Tested
2 Resampled 5/31/85; <2.2 MPN/100 mL

Fecal streptococcus bacteria analyses were conducted on samples collected June 22, 1985 from all four wells. Fecal streptococci were found only in the Lakeview Inn well. Both Group D streptococci and Streptococcus faecium were identified, which was felt to provide strong evidence of human fecal contamination of the well.

Nine of the twenty-five wells in Spalding Tract that were sampled from June 30 to July 1, 1985 were found to contain bacteria (Table 13). Four of the wells were found to contain coliform bacteria, with two of these wells also containing fecal coliform bacteria. Two of the four wells with coliform bacteria and the other five wells also

Table 13. Bacteriological results (MPN) at Spalding Tract from samples collected June 30 to July 1, 1985.

Well	Total Coliform	Fecal Coliform	Fecal Streptococcus	Group D
1. Comm. Assoc. Hall	<2.2	NT[1]	>16	positive
2. Arons	<2.2	NT	<2.2	NT
3. Brozil *(Brazil)*	<2.2	NT	2.2	negative[3]
4. Millsap	<2.2	NT	2.2	negative[3]
5. Floyd	<2.2	NT	<2.2	NT
6. Martin	<2.2	NT	<2.2	NT
7. Heritage Land Co.	<2.2	NT	<2.2	NT
8. Fluery	<2.2	NT	5.1	negative[3]
9. Hamilton	<2.2	NT	<2.2	NT
10. Webb	<2.2	NT	<2.2	NT
11. Birlem	<2.2	NT	<2.2	NT
12. Gilpatrick	2.2	2.2	<2.2	NT
13. Frey	<2.2	NT	<2.2	NT
14. Abbott	<2.2	NT	2.2	negative
15. Hart	<2.2	NT	<2.2	NT
16. Varbel	<2.2	<2.2	<2.2	NT
17. Lakeview Inn[2]	<2.2	NT	<2.2	NT
18. Varbel	16	<2.2	9.2	negative
19. Strickland	<2.2	NT	<2.2	NT
20. Stephens	<2.2	NT	<2.2	NT
21. Rice	2.2	<2.2	<2.2	NT
22. Kramer	>16	>16	9.2	negative
23. Bates	<2.2	NT	<2.2	NT
24. Groom	<2.2	NT	<2.2	NT
25. Pedrazzi *(Huber)*	<2.2	NT	<2.2	NT

[1] Not Tested
[2] Chlorinated 48 hours prior to sampling
[3] Confirmed as staphylococci rather than fecal streptococci

indicated positive results for fecal streptococci. Only one of the wells with fecal streptococci was confirmed as containing Group D organisms. Three of the other six wells indicating fecal streptococci were found instead to contain staphylococci bacteria. The other three wells positive for fecal streptococci were negative for Group D organisms. Bacterial contamination of the wells was thought to be due to the great concentration of subsurface disposal systems and individual water supply wells in areas where the hydrogeologic conditions are inappropriate as well as surface entry into the wells of non-human fecal contamination from wild and domestic animals through the predominance of poorly sealed and cased wells.

Drillers logs could not be located for most of the wells exhibiting contamination, which include the Community Association Hall, Fleury, Gilpatrick, Abbott, and Varbel wells. Area residents have reported problems with some of the wells that were used for bacterial analyses. Following analysis of the Community Association Hall well, the submerged pump was removed which lead to the discovery of a dead rat in the well which had apparently fallen in through the open top of the casing. The Fleury well was said to have not been used for a long time, but was sampled after operating for only a few minutes (as were the other wells) which would result in sampling of only the standing water in the pressure tank or casing. Mr. Brazil informed Department personnel that his well was an old, shallow, hand dug well. The Brazil's have since had a new well drilled and testing has not detected any contamination. The Millsap well has a "natural earth" seal to 30 feet, with a perforated casing from 35 feet to the bottom at 55 feet. Both the Rice and Kramer wells have natural earth seals with casings to 20 feet, and then open holes to the bottoms at 40 feet. As discussed previously, "natural earth" seals provide inadequate surface sealing to prevent shallow zone contaminants, whether from surface runoff or septic leach fields, from entering the well.

Twenty-one species of streptococcus bacteria occur and occupy a wide range of habitats, including the respiratory tract, alimentary tract, and feces of humans and animals. Groups of streptococci were established based on dominant serologically active carbohydrates which reflect distinctive antigenicity. The normal habitat of fecal streptococci is the gastrointestinal tract of warm-blooded animals (APHA 1989). However, differentiation of the source of fecal contamination based on speciation of fecal streptococci is not possible since these organisms are not host specific. Streptococcus faecium, which belongs to serological Group D, is found in the feces of humans and other warm-blooded animals, and occasionally in urinary tracts (Buchanan and Gibbons 1975; Krieg and Holt 1984). S. faecium, however, also occurs frequently in plants, insects, and the bovine alimentary tract. The subspecies S. faecium mobilis is associated with grass silage. Group D streptococci include species that occur in a variety of warm-blooded animals, including birds, cows, and horses in addition to humans, as well as plants and insects. Staphylococci bacteria are associated with the skin and mucous membranes of a wide variety of warm-blooded animals, and are common in air, soil, and dust. The presence of S. faecium

or Group D streptococci in samples collected from wells at Spalding Tract, therefore, does not indisputably indicate septic systems as the source of contamination of ground water. The presence of staphylococci bacteria from well samples, however, poses concern about contamination of samples during the collection process.

<u>**Resolution No. 85-16, Recognizing the Existence of a Public Health Problem...**</u>

The Regional Board adopted Resolution No. 85-16 on August 9, 1985, "Recognizing the Existence of a Public Health Problem at the Spalding Tract and Stones-Bengard Subdivisions Due to Contamination of Drinking Water Supply Wells from Subsurface Domestic Wastewater Disposal Systems." The recognition of a public health problem was based on results of the soil trenches, minimum criteria for separation of subsurface disposal systems and ground water, elevated nitrate nitrogen levels in downgradient wells, and incidence of bacterial contamination of wells.

<u>**Second Annual Report on the 205j Eagle Lake Index Station Productivity...**</u>

The "Second Annual Report on the 205j Eagle Lake Index Station Productivity and Routine Ground Water Nutrient Monitoring Program" was completed by the Regional Board in May, 1986. Ground water quality data from August 1984 through September 1985 was discussed for chemical analyses conducted by staff from the four monitoring wells used in previous studies (Tables 14 through 16). The data from the 1985 water year are compared to those from previous years (Table 17). Appendix A to the report contains data previously reported in the 1985 staff report on bacterial levels in drinking water wells plus some additional analyses.

Consistent differences were noted between the upgradient and downgradient wells during the 1985 water year that were similar to differences reported in previous years. Particularly perplexing was the doubling of the ortho-phosphate phosphorus concentrations from the upgradient to the mean of the downgradient wells. This was thought to be due to a high concentration of homes in Spalding Tract on small lots which have overloaded the soil mechanisms for phosphorus removal, or unusual geologic features such as lava tubes or major faults in the underlying basalt.

Table 14. Chloride analyses (mg/L) from wells at Spalding Tract during the 1985 water year.

Date	Herrbach	Downgradient Frey	Lakeview Inn	Rice	Well Mean
10/24/84	3.26	3.07	5.78	5.70	4.85
11/24/84	1.07	1.32	0.86	1.29	1.16
12/04/84	1.44	-	0.78	3.50	2.14
12/17/84	2.63	0.72	1.94	-	1.33
12/22/84	-	-	1.15	3.03	2.09
01/12/85	0.98	-	1.13	1.59	1.36
02/02/85	-	-	1.22	1.36	1.29
02/23/85	0.11	1.69	0.51	0.76	0.99
03/16/85	0.87	4.06	1.29	0.76	2.04
04/29/85	0.88	3.60	0.98	1.62	2.07
05/26/85	1.13	2.66	1.37	1.51	1.85
06/22/85	1.01	2.47	1.23	1.54	1.75
07/27/85	0.61	1.92	1.22	1.97	1.70
08/24/85	0.74	1.11	0.53	1.20	0.95
09/23/85	0.74	2.27	0.68	1.21	1.39
MEAN	1.19	2.26	1.38	1.93	1.80

Table 15. Ortho-phosphate phosphorus analyses (mg/L) from wells at Spalding Tract during the 1985 water year.

Date	Herrbach	Downgradient Frey	Lakeview Inn	Rice	Well Mean
10/24/84	0.05	0.16	0.07	0.07	0.10
11/24/84	0.05	0.15	0.06	0.05	0.09
12/04/84	0.06	-	0.06	0.07	0.07
12/17/84	0.06	0.11	0.06	-	0.09
12/22/84	-	-	0.06	0.06	0.06
01/12/85	0.09	-	0.33	0.15	0.24
02/02/85	-	-	0.13	0.37	0.25
02/23/85	0.05	0.10	0.09	0.05	0.08
03/16/85	0.05	0.13	0.07	0.06	0.09
04/29/85	0.06	0.09	0.06	0.07	0.07
05/26/85	0.06	0.16	0.09	0.08	0.11
06/22/85	0.08	0.16	0.09	0.08	0.11
07/27/85	0.04	0.11	0.06	0.06	0.08
08/24/85	0.04	0.09	0.04	0.03	0.05
09/23/85	0.05	0.12	0.09	0.07	0.09
MEAN	0.06	0.13	0.09	0.09	0.10

Results from the monitoring conducted in the 1985 water year are very similar to those from previous years. However, exceptionally high chloride concentrations, ranging from 3.07 to 5.78 mg/L in the four monitoring wells, were reported from October 24, 1984. The Herrbach well was reported to contain chloride concentrations

Table 16. Nitrate nitrogen analyses (mg/L) from wells at Spalding Tract during the 1985 water year.

		Downgradient			
Date	Herrbach	Frey	Lakeview Inn	Rice	Well Mean
10/24/84	0.19	0.63	0.13	0.37	0.38
11/24/84	0.28	2.67	0.26	0.66	1.20
12/04/84	0.15	-	0.14	0.42	0.28
12/17/84	0.09	0.60	0.18	-	0.39
12/22/84	-	-	0.16	0.92	0.54
01/12/85	0.33	-	0.18	0.45	0.32
02/02/85	-	-	0.19	0.31	0.25
02/23/85	0.36	1.88	0.13	0.18	0.73
03/16/85	0.27	2.16	0.18	0.21	0.85
04/29/85	0.07	1.44	0.09	0.36	0.63
05/26/85	0.15	1.92	0.05	0.14	0.70
06/22/85	0.24	2.17	0.16	0.62	0.98
07/27/85	0.18	1.96	0.22	0.48	0.89
08/24/85	0.58	0.99	0.09	0.21	0.43
09/23/85	0.24	2.72	0.20	0.56	1.16
MEAN	0.24	1.74	0.16	0.42	0.65

Table 17. Comparison of mean ground water quality data (in mg/L) for water years 1983, 1984, and 1985.

	Chloride			o-PO_4 Phosphorus			Nitrate nitrogen		
	1983	1984	1985	1983	1984	1985	1983	1984	1985
Herrbach	1	1.11	1.19	0.05	0.05	0.06	0.21	0.23	0.24
Frey	2	2.19	2.26	0.15	0.14	0.13	1.80	1.50	1.74
Lakeview Inn	1	1.28	1.38	0.07	0.07	0.09	0.28	0.28	0.16
Rice	2	1.63	1.93	0.07	0.06	0.09	1.60	0.35	0.42

that were greater than the Frey well. Chloride concentrations were substantially less in both the preceding and following months.

Statistical comparisons of the upgradient to downgradient wells indicate differences in occurrence of reported chloride concentrations at the 5 percent significance level for the Frey well and 1 percent significance level for the Rice well (Table 18). No statistical differences were found for the Lakeview Inn well. Differences in occurrence of ortho-phosphate phosphorus between the upgradient and downgradient wells were significant for the Frey and Rice wells, but not the Lakeview Inn well. Concentrations of ortho-phosphate phosphorus at the Rice well were very similar to those from the upgradient well except on January 12, 1985,

when analyses for all wells (except the Frey well which was not analyzed) were substantially higher than usual. Reported ortho-phosphate phosphorus concentrations were also substantially higher than normal on February 2, 1985 for the two wells (Lakeview Inn and Rice) that were monitored at that time. Differences in occurrence between upgradient and downgradient wells for nitrate nitrogen concentrations were significant only for the Frey well. The Lakeview Inn well was nearly significant at the 5 percent significance level for containing nitrate nitrogen at concentrations that were lower than in the upgradient well. The Rice well continued to show concentrations of nitrate nitrogen that are substantially lower than those reported prior to May of 1983.

Table 18. Statistical comparisons of upgradient (Herrbach) to downgradient wells for water year 1985.

Well	*Degrees of Freedom*	*Probability[1]*		
		Cl	*o-PO_4-P*	*NO_3-N*
Frey	*10*	*0.0293*	*0.0001*	*0.0001*
Lakeview	*12*	*0.3430*	*0.0863*	*0.0562*
Rice	*11*	*0.0032*	*0.0246*	*0.0785*

[1] Differences are significant where probability is 0.05 or less.

The staff report stated that the incidence of bacterial contamination was low to moderate in the summer of 1984 (Table 12), but became very pronounced in wells that were sampled during the summer of 1985 (Table 19). Bacterial contamination was not present in the winter of 1984-85, but was present in the late winter of 1985-86. Increasing bacterial contamination or different temperature and precipitation patterns were thought to play a role in the increased contamination. *Only the 4 routine monitoring wells were sampled for bacterial contamination during the spring of 1984 to spring of 1985 (Table 12), of which 3 indicated bacterial contamination. Eight occurrences of bacterial contamination were reported from these 4 wells in this period. During the summer of 1985 to spring of 1986 (Table 19), bacterial contamination was again reported from 3 of these 4 wells, but only for a total of 6 occurrences. The incidence of bacterial contamination did not increase in 1985 from that reported in 1984. However, the magnitude of reported contamination was greater in 1985-86 than 1984-85. While most probable number estimates of bacterial contamination in 1984-85 was 2.2 bacteria per 100 mL for each*

occurrence, estimates of bacterial contamination in 1985-86 ranged to as great as 9.2 bacteria per 100 mL on two occasions.

Table 19. Coliform bacteria (MPN) analyses of wells at Spalding Tract from July 27, 1985 through March 22, 1986.

Well	7/27/85	8/24/85	9/23/85	10/26/85	12/2/85	12/22/85	2/1/86	2/22/86	3/22/86
	TC	TC	TC	TC	TC	TC	TC	TC	TC
Herrbach	<2.2	<2.2	<2.2	<2.2	<2.2	NT[1]	2.2	5.1	<2.2
Frey	<2.2	<2.2	<2.2	<2.2	<2.2	<2.2	<2.2	NT	NT
Lakeview Inn	<2.2	5.1	<2.2	<2.2	<2.2	<2.2	<2.2	<2.2	<2.2
Rice	9.2	<2.2	<2.2	9.2	<2.2	<2.2	<2.2	5.1	<2.2

[1] Not Tested

Twenty-two additional wells were sampled on June 30 and July 1, 1985 (Table 13). Bacterial contamination was detected in samples from 9 of the 25 wells sampled during this period. Wells sampled for bacterial contamination at Spalding Tract during July 27 and 29, 1985 (Table 20) included only those that had shown bacterial contamination the previous year, with the exception of the Nutt well which was not previously sampled. Wells sampled that exhibited contamination the previous year would be expected to be ones most likely to exhibit continued contamination. A high rate of bacterial contamination was found in this subsequent sampling because only those wells previously found to be contaminated were resampled. However, bacterial contamination did not become more pronounced in the subsequent sampling, but in fact decreased since one of the wells previously showing contamination did not subsequently exhibit contamination.

Table 20. Additional bacterial analyses (MPN) conducted on selected wells at Spalding Tract during July 27 and July 29, 1985.

Well	July 27, 1985	July 29, 1985		
	TC	TC	FC	FS
E.L. Comm. Assoc.	16	2.2	<2.2	>16
Bronzil (Brazil)	NT[1]	9.2	5.1	<2.2
Varbel	NT	16	<2.2	9.2
Millsap	NT	<2.2	NT	<2.2
Nutt	NT	2.2	<2.2	<2.2

[1] Not Tested

Sufficient data are not available to establish trends for the occurrence of contamination. Although two of the routine monitoring wells in Spalding Tract exhibited contamination during the late winter of 1985-86 that was not apparent during the winter of 1984-85, the opposite occurred in the spring when contamination present during the spring of 1984-85 was not present during the corresponding period of 1985-86. The data do not indicate increasing bacterial contamination.

Third Annual Report on the 205j Eagle Lake Index Station Productivity ...

Ground water quality data collected during the 1986 water year are discussed in the "Third Annual Report on the 205j Eagle Lake Index Station Productivity and Routine Ground Water Nutrient Monitoring Program." Analyses for chloride, ortho-phosphate phosphorus, nitrate nitrogen, and coliform bacteria were reported.

Regional Board staff noted continuing consistent differences in concentrations of chloride (Table 21), ortho-phosphate phosphorus (Table 22), and nitrate nitrogen (Table 23) between the mean of the monthly analyses from the upgradient well and the mean of the monthly means from each downgradient well.

Table 21. Chloride analyses (mg/L) from wells at Spalding Tract during the 1986 water year.

		Downgradient			
Date	Herrbach	Frey	Lakeview Inn	Rice	Well Mean
10/26/85	0.30	1.01	0.25	1.62	0.96
12/02/85	0.43	2.28	0.72	0.57	1.19
12/23/85	-	-	1.28	1.78	1.53
02/01/86	1.02	3.63	1.00	1.43	2.02
02/22/86	0.77	-	0.73	0.79	0.76
03/22/86	0.24	-	0.47	0.23	0.35
04/26/86	0.36	2.49	1.17	-	1.83
05/30/86	0.99	-	1.31	-	1.31
06/25/86	0.72	2.70	1.29	0.80	1.60
07/24/86	0.76	2.65	1.29	1.14	1.69
08/23/86	0.95	1.98	1.19	1.40	1.52
09/22/86	0.84	2.00	1.06	1.27	1.44
MEAN	0.67	2.34	0.98	1.10	1.35

Table 22. Ortho-phosphate phosphorus analyses (mg/L) from wells at Spalding Tract during the 1986 water year.

		Downgradient			
Date	Herrbach	Frey	Lakeview Inn	Rice	Well Mean
10/26/85	0.05	0.15	0.07	0.06	0.09
12/02/85	0.05	0.12	0.07	0.07	0.09
12/23/85	-	-	0.03	0.03	0.03
02/01/86	0.03	0.07	0.03	0.02	0.04
02/22/86	0.04	-	0.03	0.04	0.04
03/22/86	0.03	-	0.07	0.03	0.05
04/26/86	0.04	0.11	0.07	-	0.09
05/30/86	0.05	-	0.07	-	0.07
06/25/86	0.05	0.16	0.07	0.05	0.09
07/24/86	0.06	0.17	0.07	0.07	0.10
08/23/86	0.06	0.12	0.08	0.05	0.08
09/22/86	0.06	0.16	0.06	0.02	0.08
MEAN	0.05	0.13	0.06	0.04	0.07

Table 23. Nitrate nitrogen analyses (mg/L) from wells at Spalding Tract during the 1986 water year.

		Downgradient			
Date	Herrbach	Frey	Lakeview Inn	Rice	Well Mean
10/26/85	0.22	2.20	0.16	0.63	1.00
12/02/85	0.27	1.92	0.19	0.49	0.87
12/23/85	-	-	0.19	0.43	0.31
02/01/86	0.25	1.68	0.16	0.68	0.84
02/22/86	0.25	-	0.15	0.92	0.54
03/22/86	0.17	-	0.22	0.21	0.22
04/26/86	0.18	5.90	0.24	-	3.07
05/30/86	0.25	-	0.24	-	0.24
06/25/86	0.12	2.46	0.18	0.17	0.94
07/24/86	0.12	2.69	0.19	0.28	1.05
08/23/86	0.19	1.45	0.14	0.39	0.66
09/22/86	0.22	2.84	0.21	0.02	1.02
MEAN	0.20	2.64	0.19	0.42	0.90

Chloride concentrations from the upgradient Herrbach well were substantially less in the 1986 water year than in previous water years, but still exhibited wide fluctuations from month to month. Both the Lakeview Inn and Rice wells also exhibited chloride concentrations during the 1986 water year that were substantially less than those reported during previous water years. Chloride concentrations in the Frey well, however, remained about the same as those found in previous water years. Chloride levels during the 1986 water year were only slightly greater in the Lakeview Inn and Rice wells than the upgradient Herrbach well.

Mean ortho-phosphate phosphorus concentrations remained essentially unchanged in the upgradient Herrbach and downgradient Frey wells during the 1986 water year, while concentrations decreased substantially in both the Lakeview Inn and Rice wells from those present in previous years. The mean ortho-phosphate phosphorus concentrations for 1986 were essentially the same in the Herrbach, Lakeview Inn, and Rice wells.

Concentrations of nitrate nitrogen were the same in the Lakeview Inn and Herrbach wells, but were somewhat higher in the Rice well. Nitrate nitrogen concentrations reported from the Rice well continued to be substantially lower than those reported prior to May of 1983. The Frey well continued to exhibit substantially greater concentrations of nitrate nitrogen than any of the other wells.

Differences in occurrence of chloride are statistically significant between the upgradient and each downgradient well (Table 24). Differences in ortho-phosphate phosphorus occurrences are statistically significant between the upgradient well and both the Frey and Lakeview Inn wells. Differences in occurrence of nitrate nitrogen reported between the Herrbach and both the Frey and Rice wells are statistically significant.

Table 24. Statistical comparisons of upgradient (Herrbach) to downgradient wells for water year 1986.

Well	Degrees of Freedom	Probability[1]		
		Cl	$o\text{-}PO_4\text{-}P$	$NO_3\text{-}N$
Frey	7	0.0002	0.0001	0.0018
Lakeview Inn	10	0.0063	0.0052	0.4792
Rice	8	0.0295	0.7078	0.0327

[1] *Differences are significant where probability is 0.05 or less.*

The incidence of bacterial contamination was noted to increase during the summer months after a lack of contamination observed during the spring of 1986 (Table 25). *However, while bacterial contamination had been found during previous summer months from each of the monitoring wells, coliform bacteria were found only from the Frey well during the summer of 1986. The multiple-tube fermentation technique yielded numbers of bacteria higher than previously found in the Frey*

Table 25. Coliform bacteria (MPN) analyses of wells at Spalding Tract in 1986.

Well	4/26/86		5/25/86		6/25/86		7/24/86		8/23/86		9/22/86	
	TC	FC	TC	FC	TC	FC	TC	FC	TC	FC	TC	FC
Herrbach	<2.2	NT[1]	<2.2	NT	<2.2	NT	<2.2	NT	<2.2	NT	<2.2	NT
Frey	<2.2	NT	<2.2	NT	>16	<2.2	2.2	<2.2	5.1	<2.2	2.2	NT
Lakeview Inn	<2.2	NT	<2.2	NT	<2.2	NT	<2.2	NT	<2.2	NT	<2.2	NT
Rice	<2.2	NT	<2.2	NT	<2.2	NT	<2.2	NT	<2.2	NT	<2.2	NT

[1] Not Tested

well, but the incidence of bacterial contamination had not increased. No fecal coliform bacteria were detected.

No further monitoring of Spalding Tract was proposed since the data were felt to adequately demonstrate the existence of ground water contamination from septic tanks and leachfields.

Overall statistical comparison of the chemical data collected since 1983 show significant differences between the upgradient Herrbach well and each downgradient well for each parameter, except nitrate nitrogen occurrence in the Lakeview Inn well (Table 26). Such analyses indicate that water quality differences exist between the upgradient and each downgradient well. However, as discussed previously, ground water is expected to change in characteristics depending upon geological features through which the water passes, as well as possible contamination. The downgradient wells would not be expected to be exactly like the upgradient wells, since natural and possibly artificial (pollution) sources of minerals and nutrients could be expected to alter the water characteristics. In addition, ground water at the upgradient well, with chemical characteristics that vary with time, could take weeks or months to travel to the downgradient wells. Ground water quality is thus not strictly comparable for samples collected on the same day from upgradient and downgradient wells since the initial chemical characteristics are different. Statistical comparisons of wells are more useful for determining where no differences in quality occur than where there are differences.

Table 26. Statistical comparisons of upgradient (Herrbach) to downgradient wells for water years 1983 through 1986.

Well	Degrees of Freedom	Probability[1] Cl	$o\text{-}PO_4\text{-}P$	$NO_3\text{-}N$
Frey	33	0.0001	0.0001	0.0001
Lakeview	40	0.0074	0.0009	0.8125
Rice	42	0.0001	0.0002	0.0003

[1] Differences are significant where probability is 0.05 or less.

Annual mean concentrations of chloride, ortho-phosphate phosphorus, and nitrate nitrogen have been substantially greater in the Frey well than in any of the other wells since monitoring began in 1983 (Table 27). The greater concentrations from the Frey well tend to bias the mean of the downgradient well means used in comparisons with the upgradient well mean for each parameter. The mean of each parameter in the downgradient wells was generally greater than the mean in the upgradient well (Figures 6, 7, and 8) during each water year largely due to the elevated concentrations in the Frey well.

Table 27. Comparison of mean monthly ground water quality data (in mg/L) for water years 1983 through 1986.

	Chloride				$o\text{-}PO_4$ Phosphorus				Nitrate nitrogen			
	1983	1984	1985	1986	1983	1984	1985	1986	1983	1984	1985	1986
Herrbach	1	1.11	1.19	0.67	0.05	0.05	0.06	0.05	0.21	0.23	0.24	0.20
Frey	2	2.19	2.26	2.34	0.15	0.14	0.13	0.13	1.8	1.50	1.74	2.64
Lakeview Inn	1	1.28	1.38	0.98	0.07	0.07	0.09	0.06	0.28	0.28	0.16	0.19
Rice	2	1.63	1.93	1.10	0.07	0.06	0.09	0.04	1.6	0.35	0.42	0.42

Chloride concentrations measured since October 1982 have been highly variable in each of the four monitoring wells (Figure 9). No trend of increasing chloride concentrations are apparent. The upgradient Herrbach well at times contained chloride concentrations that were greater than at least some of the downgradient wells. Overall, the mean, maximum, and minimum chloride concentrations in the Herrbach well were lower than the other wells (Table 28). The Frey well most consistently contained the greatest chloride concentrations. However, the greatest chloride concentrations were reported from the Lakeview Inn and Rice wells in

Figure 6. Mean monthly chloride concentrations (mg/L) from upgradient (Herrbach) and downgradient (Frey, Lakeview Inn, and Rice) wells.

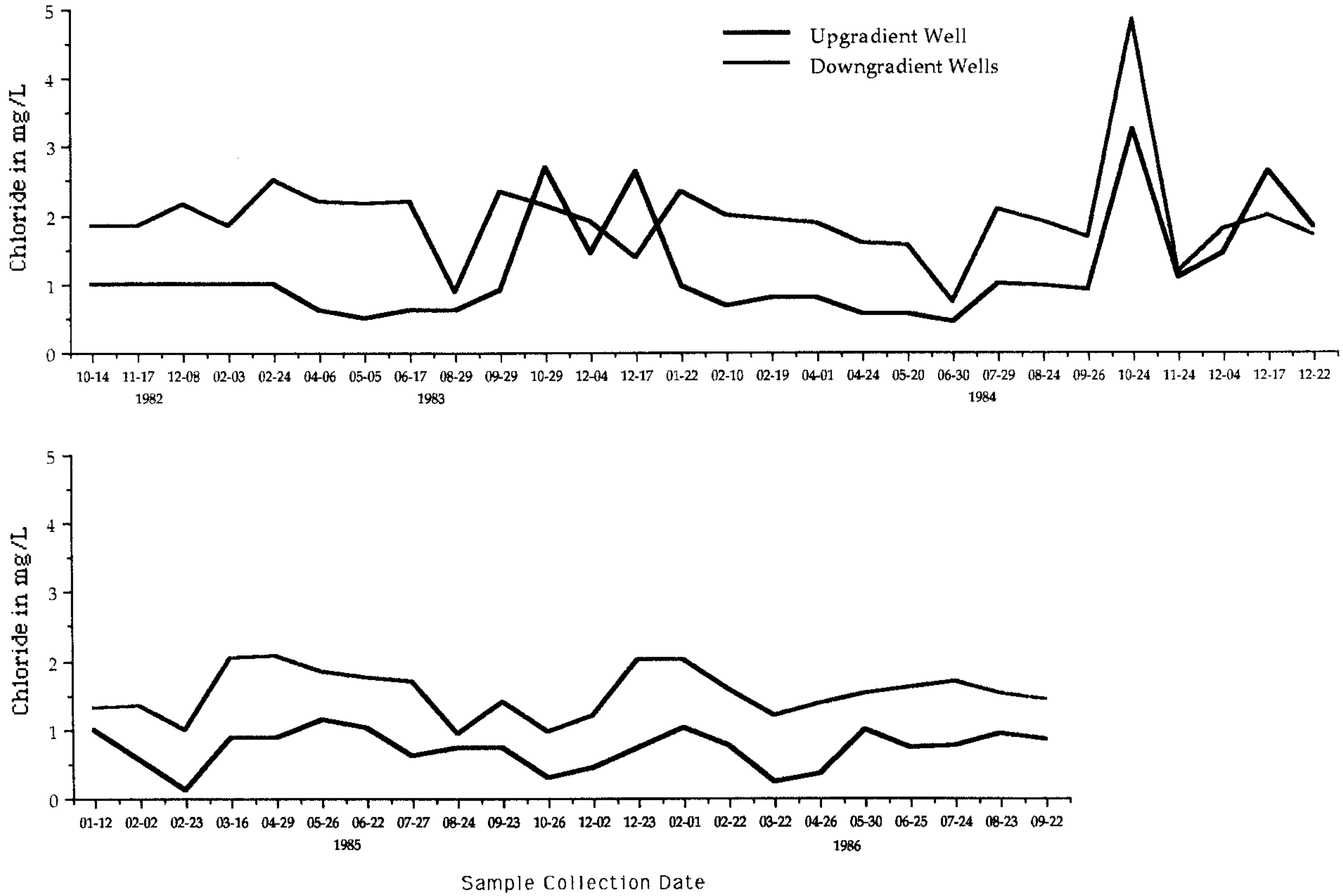


Figure 7. Mean monthly ortho-phosphate phosphorus concentrations (mg/L) from upgradient (Herrbach) and downgradient (Frey, Lakeview Inn, and Rice) wells.

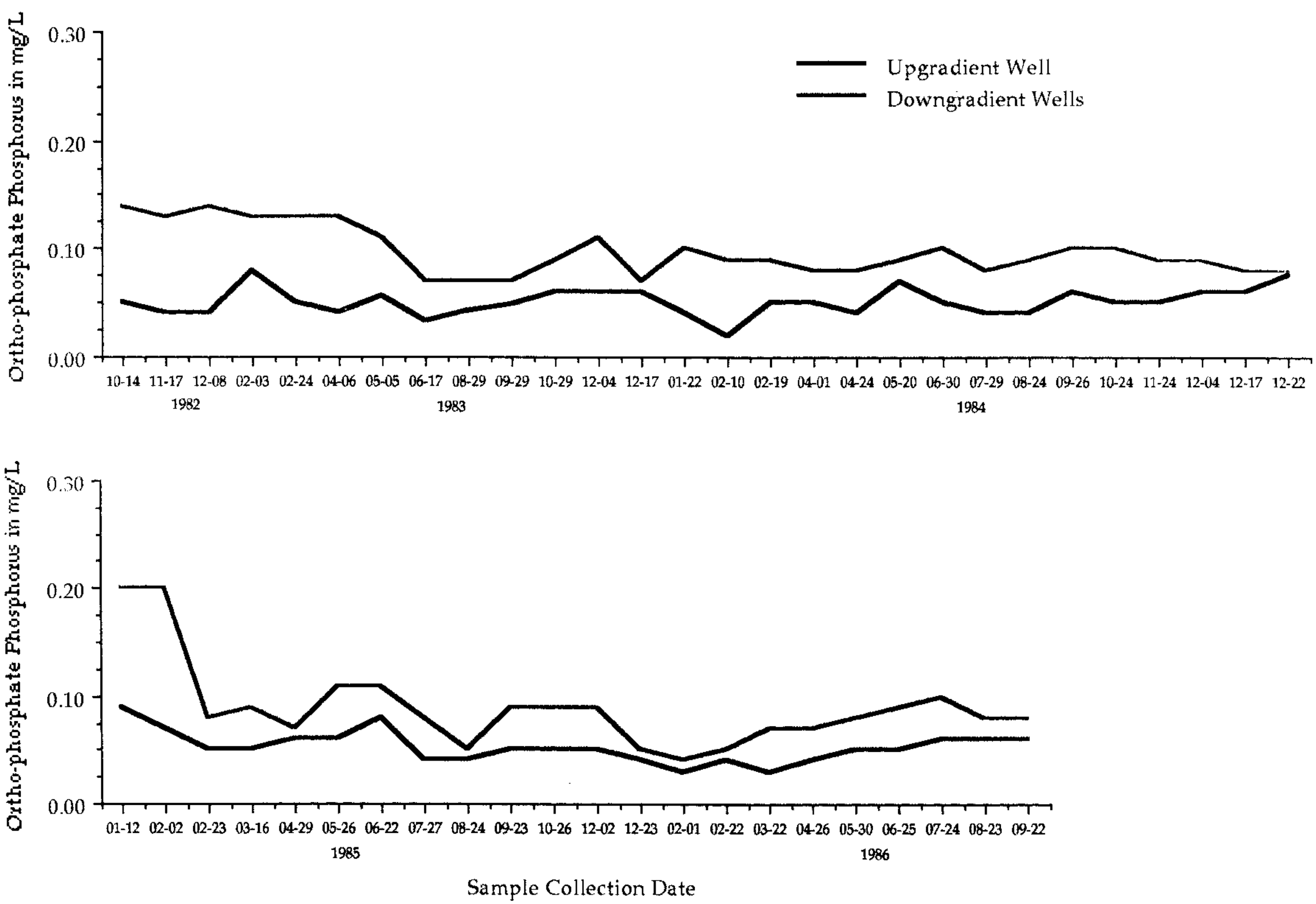


Figure 8. Mean monthly nitrate nitrogen concentrations (mg/L) from upgradient (Herrbach) and downgradient (Frey, Lakeview Inn, and Rice) Wells.

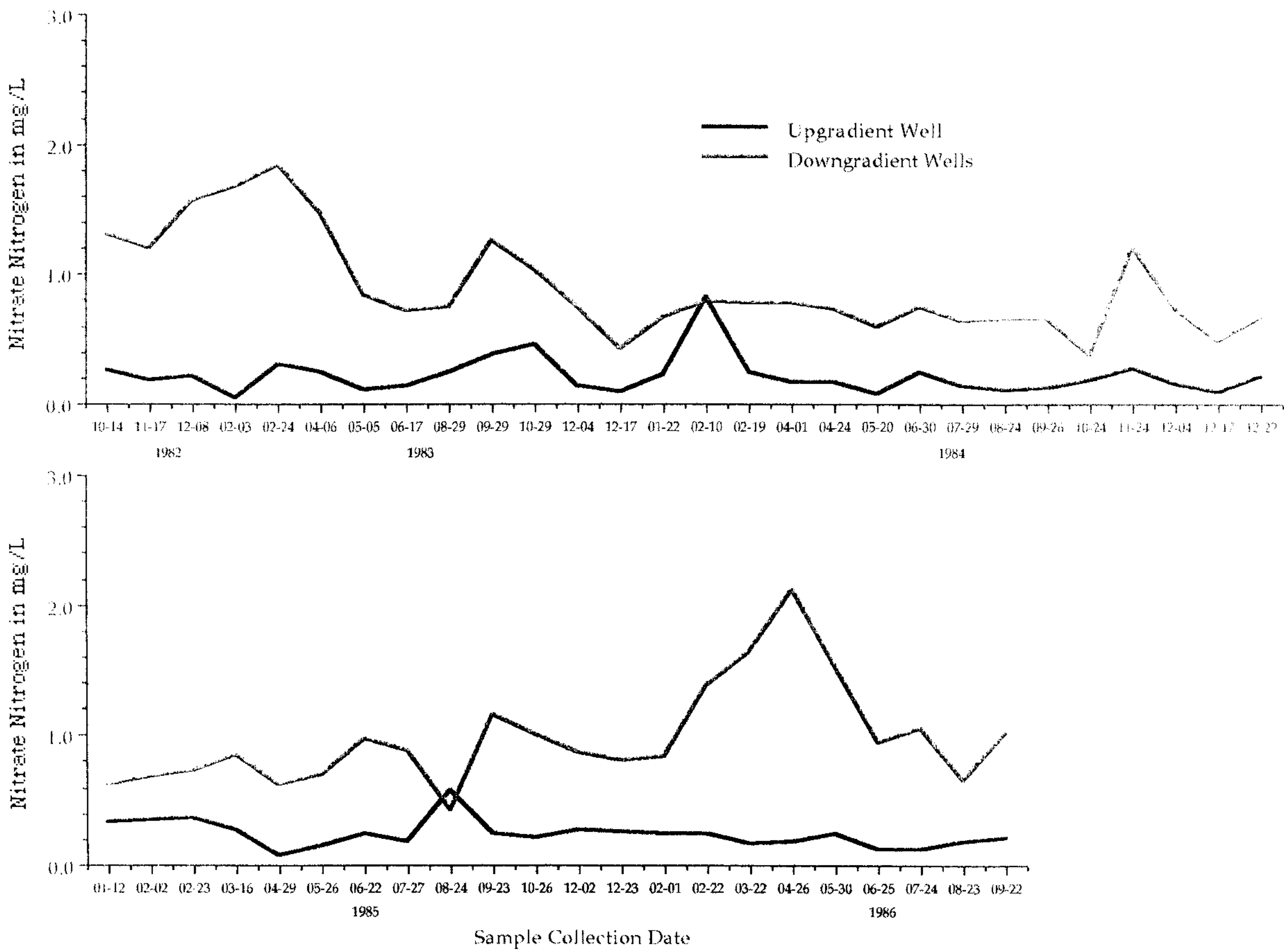


Figure 9. Chloride analyses from monitoring wells at Spalding Tract from October 1982 to September 1986.

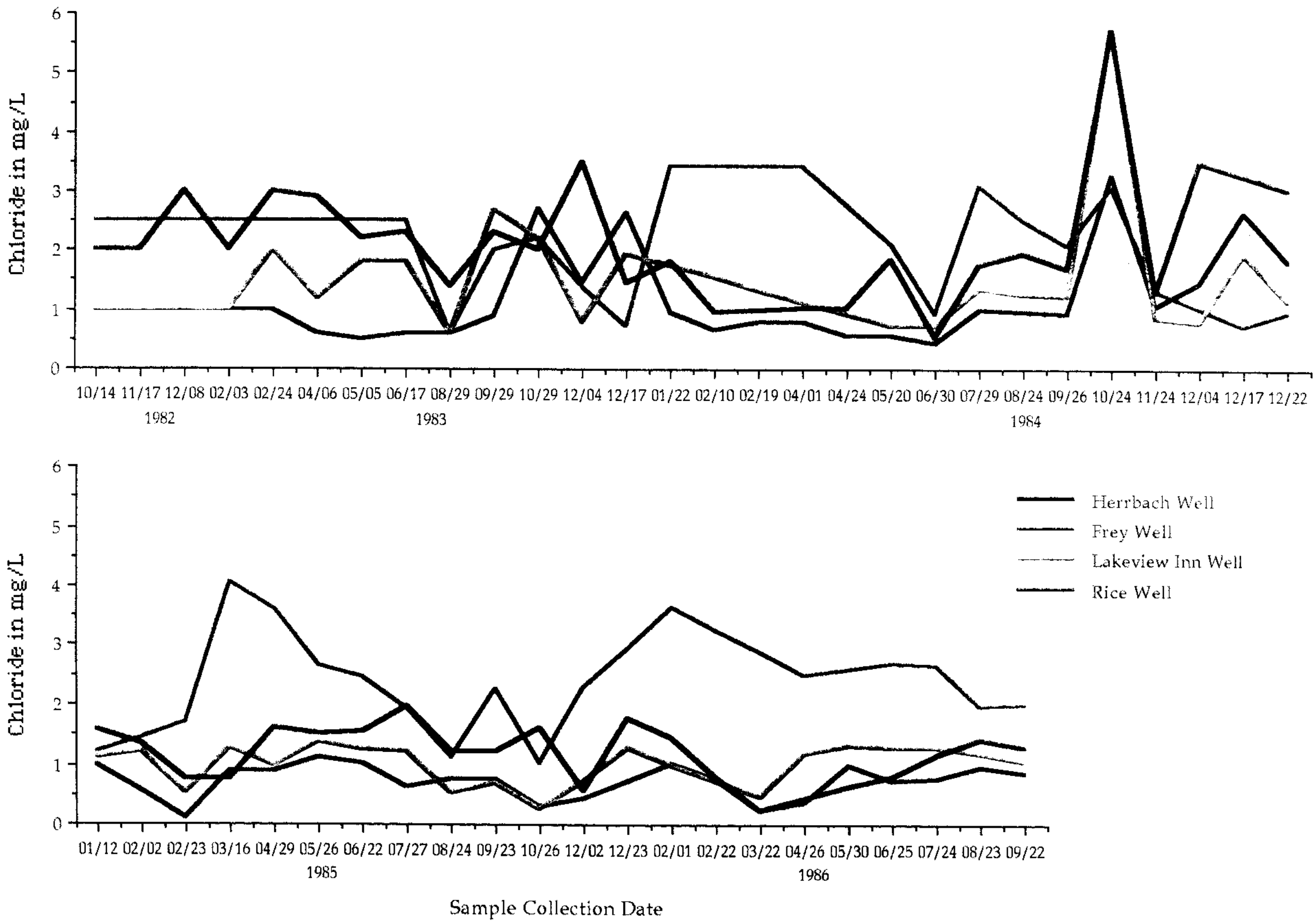


Table 28. Mean, minimum, and maximum concentrations of chloride, ortho-phosphate phosphorus, and nitrate nitrogen from wells in Spalding Tract for water years 1983 through 1986.

	Chloride			o-PO_4 Phosphorus			Nitrate nitrogen		
	Mean	Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.
Herrbach	0.97	3.26	0.11	0.05	0.09	0.02	0.22	0.82	0.05
Frey	2.23	4.06	0.60	0.14	0.25	0.07	1.89	5.90	0.60
Lakeview Inn	1.27	5.78	0.25	0.07	0.33	0.03	0.22	0.85	0.05
Rice	1.75	5.70	0.23	0.07	0.37	0.02	0.67	3.30	0.02

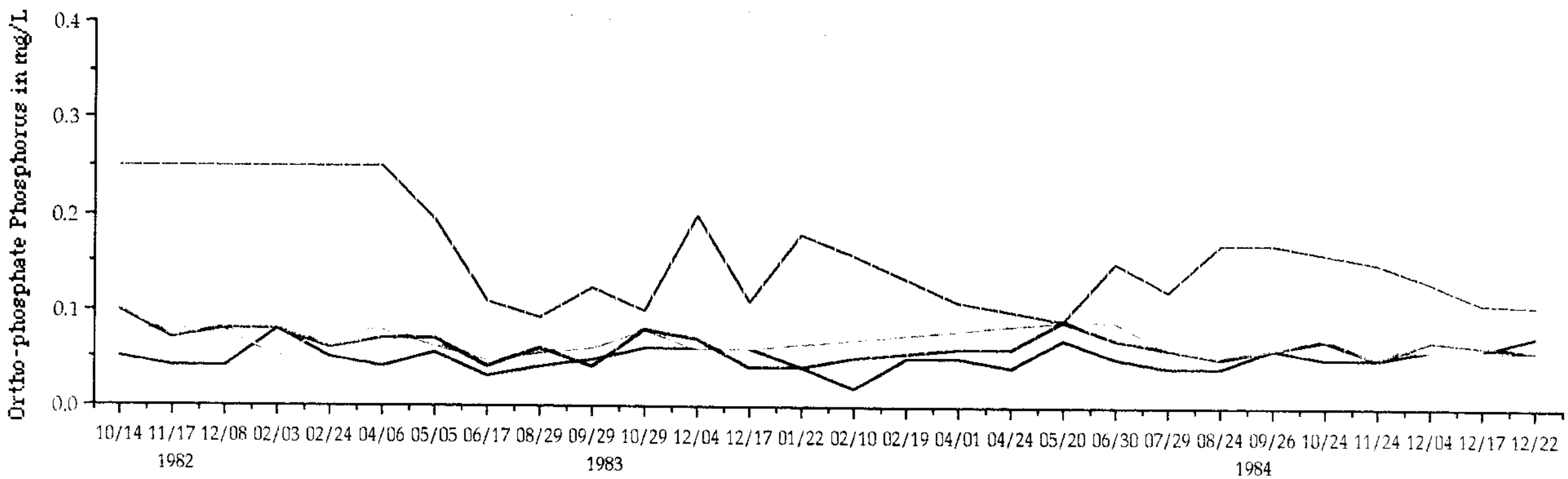
October 1984, with the Frey well containing the least chloride concentration. Analytical error may be responsible for these inconsistent results. Chloride concentrations since late 1984 have been very similar between the upgradient Herrbach well and downgradient Lakeview Inn and Rice wells.

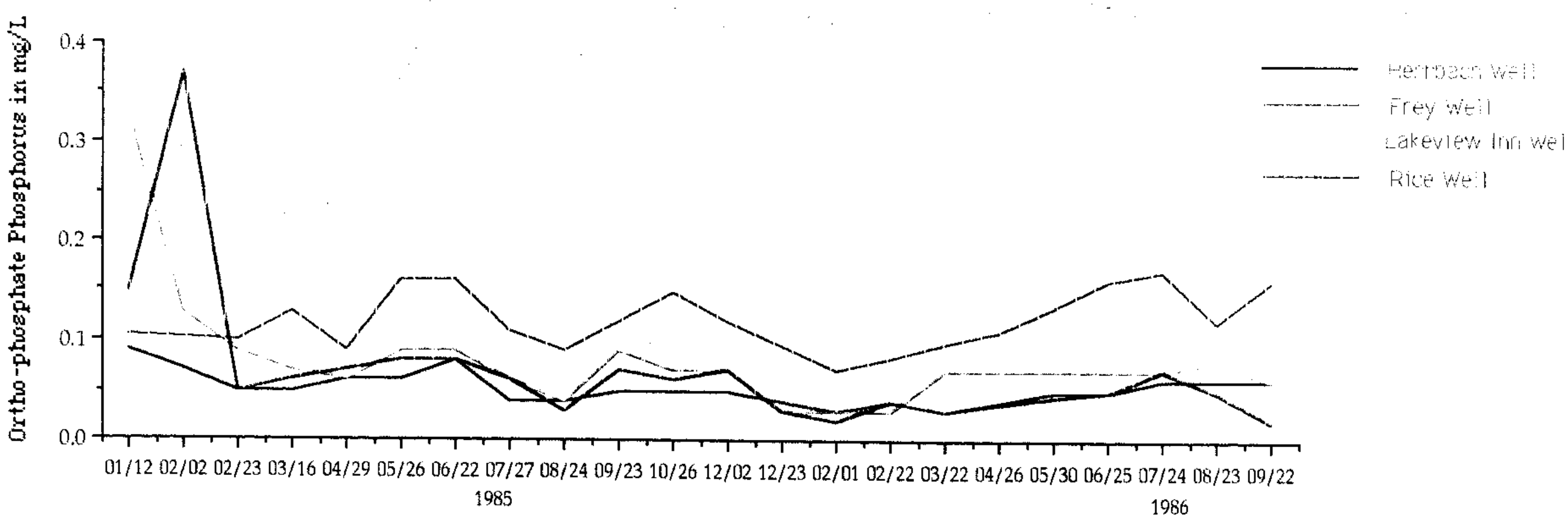
Except for unusually high reported concentrations in 1985 during January from the Lakeview Inn well and February from the Rice well, ortho-phosphate phosphorus concentrations have been very similar between the Herrbach, Lakeview Inn, and Rice wells (Figure 10). The Frey well has demonstrated consistently elevated concentrations of ortho-phosphate phosphorus. No trend of increasing concentrations of ortho-phosphate phosphorus are evident.

Nitrate nitrogen concentrations in the Rice well were substantially greater than the upgradient Herrbach well until June 1983 (Figure 11). Since June 1983, the Herrbach, Lakeview Inn, and Rice wells have been very similar in nitrate nitrogen concentrations, while the Frey well has consistently contained substantially greater concentrations. The nitrate nitrogen data do not indicate any trends of increasing concentrations.

Bacterial contamination has been found from both upgradient and downgradient wells (Figure 12). The greatest level of bacterial contamination was reported from the Frey well, which also exhibited the greatest frequency of occurrence. No patterns of occurrence are evident from any well, nor did contamination occur consistently from month to month in any well except the Frey well during the summer of 1984 and 1986, but not during the summer of 1985. The other downgradient wells did not exhibit bacterial contamination at any greater frequency than the upgradient well.

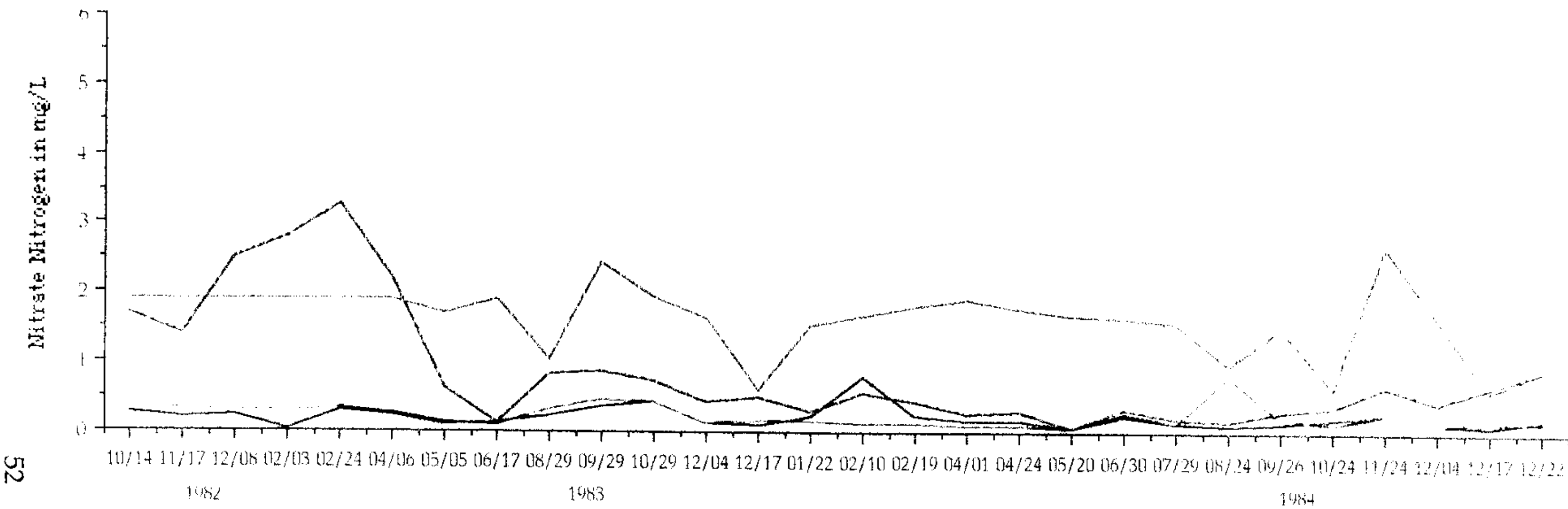
Figure 10. Ortho-phosphate phosphorus analyses from monitoring wells at Spalding Tract from October 1982 to September 1986.





Sample Collection Date

Figure 11. Nitrate nitrogen analyses from monitoring wells at Spalding Tract from October 1982 to September 1986.



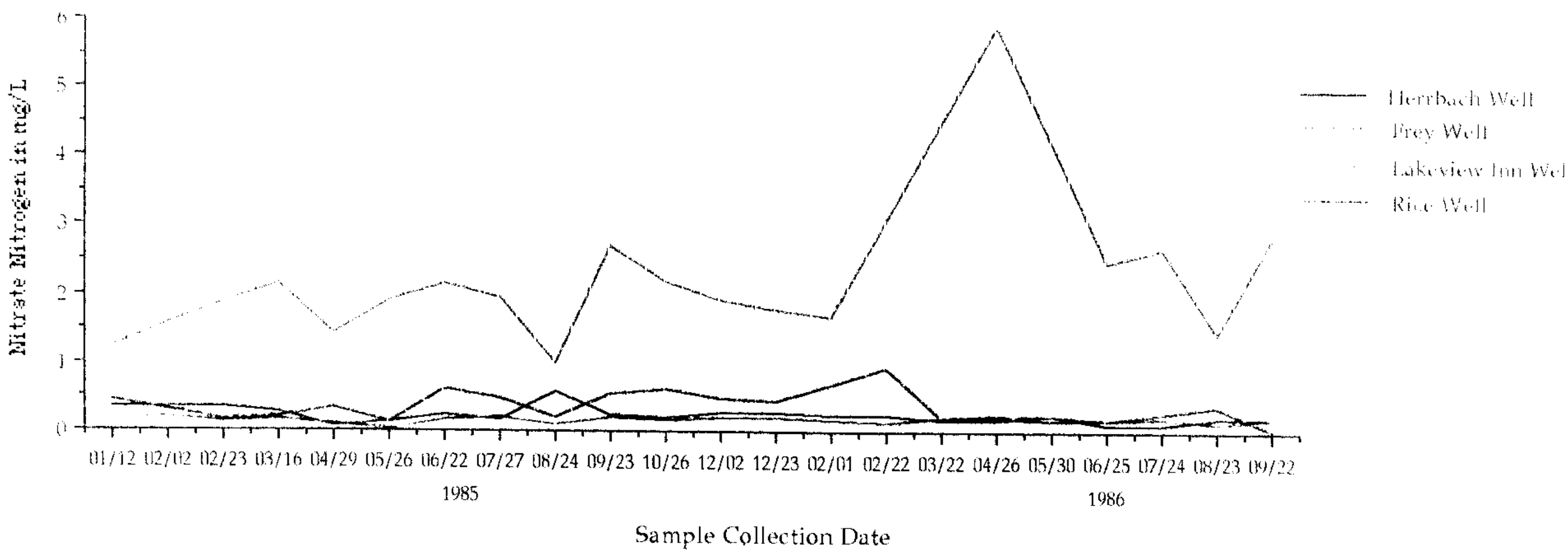
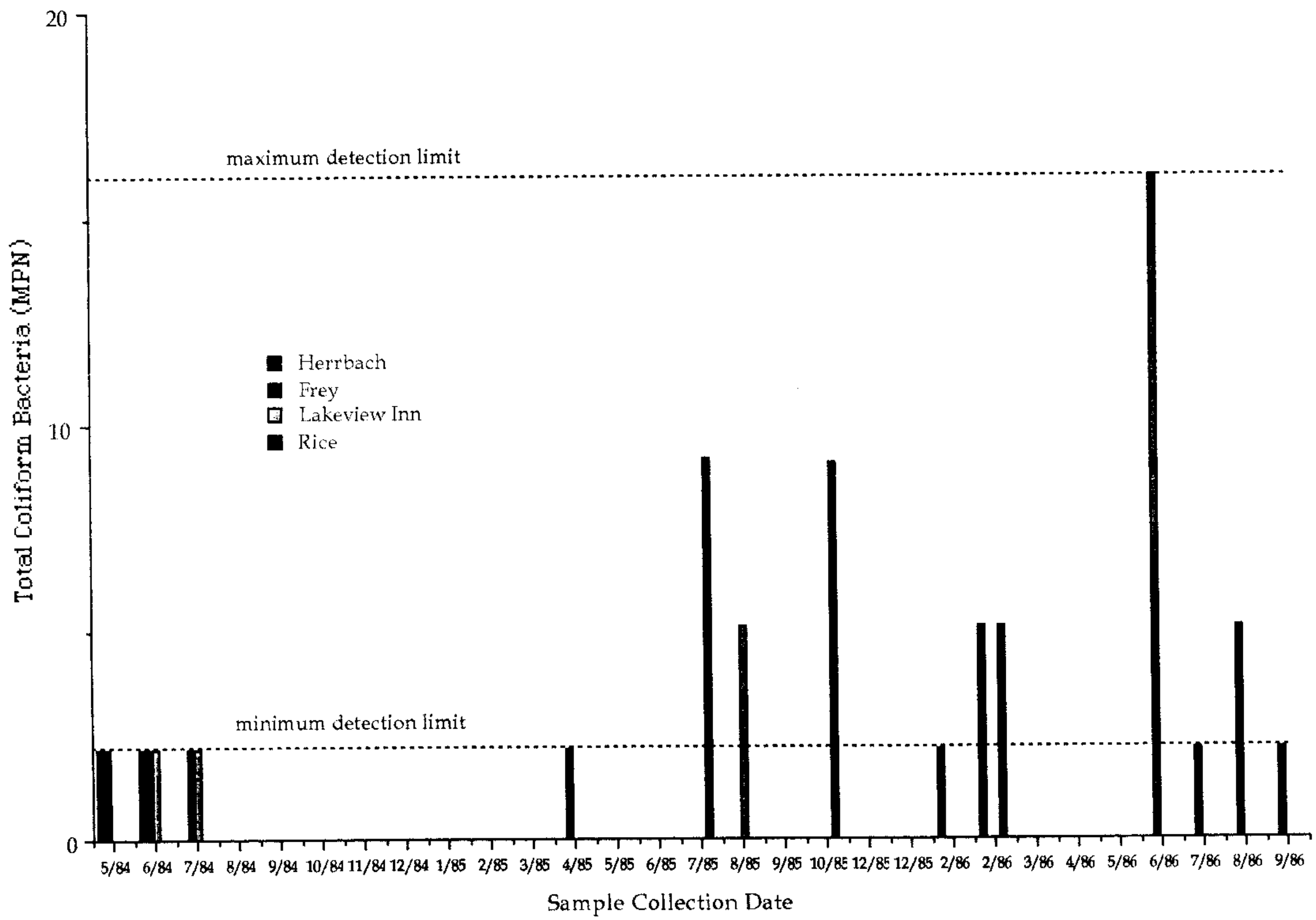


Figure 12. Total coliform bacteria (MPN) from upgradient (Herrbach) and downgradient (Frey, Lakeview Inn, and Rice) wells.



Resolution No. 87-14. Reaffirming the Adoption of the Amendment...

In response to a petition signed by property owners, the Regional Board held a "Public Hearing in the Matter of a Request for Amendments to the Water Quality Control Plan for the North Lahontan Basin" on July 10, 1987. The petitioners requested rescission or modification of the portion of the Basin Plan that prohibited discharge of waste with other than a zero discharge of nutrients to any surface water or ground water in the Eagle Lake Basin after September 14, 1989.

Staff argued that sufficient evidence had been developed to support the prohibition. Sixty-five percent of the 48 backhoe trenches in Spalding Tract had been determined to contain soils unacceptable for individual leachfield systems. Five years of ground water monitoring had demonstrated that downgradient wells contained statistically significantly greater concentrations of nitrate nitrogen, ortho-phosphate phosphorus, and chloride than the upgradient well. Since ground water flow was toward Eagle Lake, the increased levels of nutrients in the ground water were considered to be contributing to accelerated eutrophication. Nine of the 25 wells that were analyzed for bacterial contamination in Spalding Tract tested positive. Four of the wells were found to contain coliform bacteria, with two of these also containing fecal coliform. Two of the four wells and the other five wells also indicated positive for fecal streptococci, of which only one was confirmed as Group D streptococci. However, three of the wells positive for streptococci were found instead to contain staphylococci. The staff report noted a trend of more frequent bacterial contamination in downgradient wells. Staff summarized that the significant bacterial contamination of drinking water supply wells is most likely the result of a concentration of subsurface disposal systems and individual water supply wells in areas where the hydrogeologic conditions are extremely inappropriate.

Results from bacterial sampling of wells by property owners were presented by one of the petitioners (Table 29). Six of the 29 wells sampled were positive for total coliform bacteria. The petitioners proposed development of a well and septic tank maintenance program as an alternative to the prohibition. Staff rejected this proposal stating that neither Eagle Lake nor ground water would be protected from long term nutrient loading. *The Strickland well contained high numbers of* *coliform bacteria. Area residents report that the pressure tank, pump, and well casing were badly rusted and corroded. Following replacement of the tank, pump, and casing, coliform bacteria were not detected from additional analyses.*

Table 29. Total coliform bacteria from wells sampled by property owners.

Well	Date	Testing Method	Total Coliforms
Artian	4/15/87	MF[1]	0
Bell	4/22/87	MF	0
Birlem	5/10/87	MF	0
Boyles	4/15/87	MF	4
	5/10/87	MF	2
Brochon	5/17/87	MF	0
Comm. Hall	10/3/86	MPN[2]	<2.2
	4/15/87	MF	0
E. L. Store	4/15/87	MF	0
Ebaugh	5/17/87	MF	0
Eck	5/17/87	MF	3
Fleury	8/15/86	MPN	<2.2
Heritage Realty	5/3/87	MF	0
Hillyard	4/19/87	MF	1
Iris	5/10/87	MF	0
Lakeview Inn	5/29/85	MPN	<2.2
	7/2/85	MPN	<2.2
	10/29/85	MPN	<2.2
	4/19/85	MF	0
Miller	5/10/87	MF	1
Milsapps	10/3/86	MPN	<2.2
Morgan	3/29/87	MF	0
Patrick	5/17/87	MF	0
Reed	3/17/87	MF	0
Stebbins	5/17/87	MF	0
Stout	5/10/87	MF	0
Tingley	5/17/87	MF	6
Tomasini	3/29/87	MF	0
Strickland	5/17/87	MF	47
Turek	5/10/87	MF	0
Healy	3/17/87	MF	0
	5/17/87	MF	0
Varbel	10/3/86	MPN	0
Weaver	5/10/87	MF	0
Zunino	5/10/87	MF	0
	5/17/87	MF	0

[1] Membrane filter
[2] Most Probable Number

The Regional Board adopted Resolution No. 87-14, "Reaffirming the Adoption of the Amendment to the Water Quality Control Plan for the North Lahontan Basin Concerning the Eagle Lake Hydrologic Unit." This resolution denied the request of property owners to rescind or modify the previously approved amendment to the Water Quality Control Plan. The Regional Board determined that water quality and public health problems exist and can be attributed to the discharge of waste to subsurface disposal systems, and that these problems will progressively increase as development continues or length of residency increases at Spalding Tract.

Ground Water Quality Study of Spalding Tract ...

The report "Ground Water Quality Study of Spalding Tract, Eagle Lake, Lassen County, California" was completed on January 5, 1989 as part of the requirements for the degree of Master of Science in Hydrology and Hydrogeology at the University of

Nevada at Reno (Ruefer 1989). Chemical analyses of water samples were made from wells throughout Spalding Tract from August 30 to November 1, 1987 and May 8 to May 30, 1988. Depth to water measurements were made from most of the same wells in October 1987 and May 9, 1988. Samples for bacterial analyses, using membrane filtration, were collected only in the fall of 1987. Water was run from a tap near sampled wells for a minimum of 5 minutes prior to sample collection. The Nevada State Health Laboratory in Reno conducted the analyses for total dissolved solids, chloride, nitrate, ortho-phosphate phosphorus, and bacteria. The study proposal for this work stated that bacterial analyses would be conducted within 30 hours after collection.

Average well depth was assumed to be 90 feet, based on discussions with property owners. Depth to ground water measured in 35 wells during the fall of 1987 ranged from 11.19 feet near the lake to 42.35 feet further inland. Ground water elevation ranged from 5,105.39 to 5,108.65 feet (Figure 13). The ground water gradient was determined to be 0.40 feet/1,000 feet, sloping toward the lake. The lake level was stated to be about 1.4 feet below ground water level. In general, the spring 1988 ground water levels measured in 34 wells were about 0.2 feet higher than the previous fall, ranging from 11.15 to 41.15 feet below ground level. The ground water slope was determined to be 0.33 feet/1,000 feet toward the lake. Ground water elevation in the spring ranged from 5,105.90 to 5,108.83 feet. Lake elevation was 5,106.16 feet above sea level, which was about 1.1 feet lower than water levels in wells near the lake. Mounds and other contour irregularities during the fall and spring were attributed to nearby pumping, lawn irrigation, or measurement error.

Well numbers assigned by the Department of Water Resources should be used for well identification. Use of a non-standard well numbering system makes it virtually impossible to review well lithology or resample any wells used in this study for confirmation of results during subsequent studies.

Average well depth in the subdivision determined from drillers logs is about 65 feet.

Most of the wells measured for water level are located near the lake. Contours in some parts of the subdivision were plotted with little actual data. Contours were

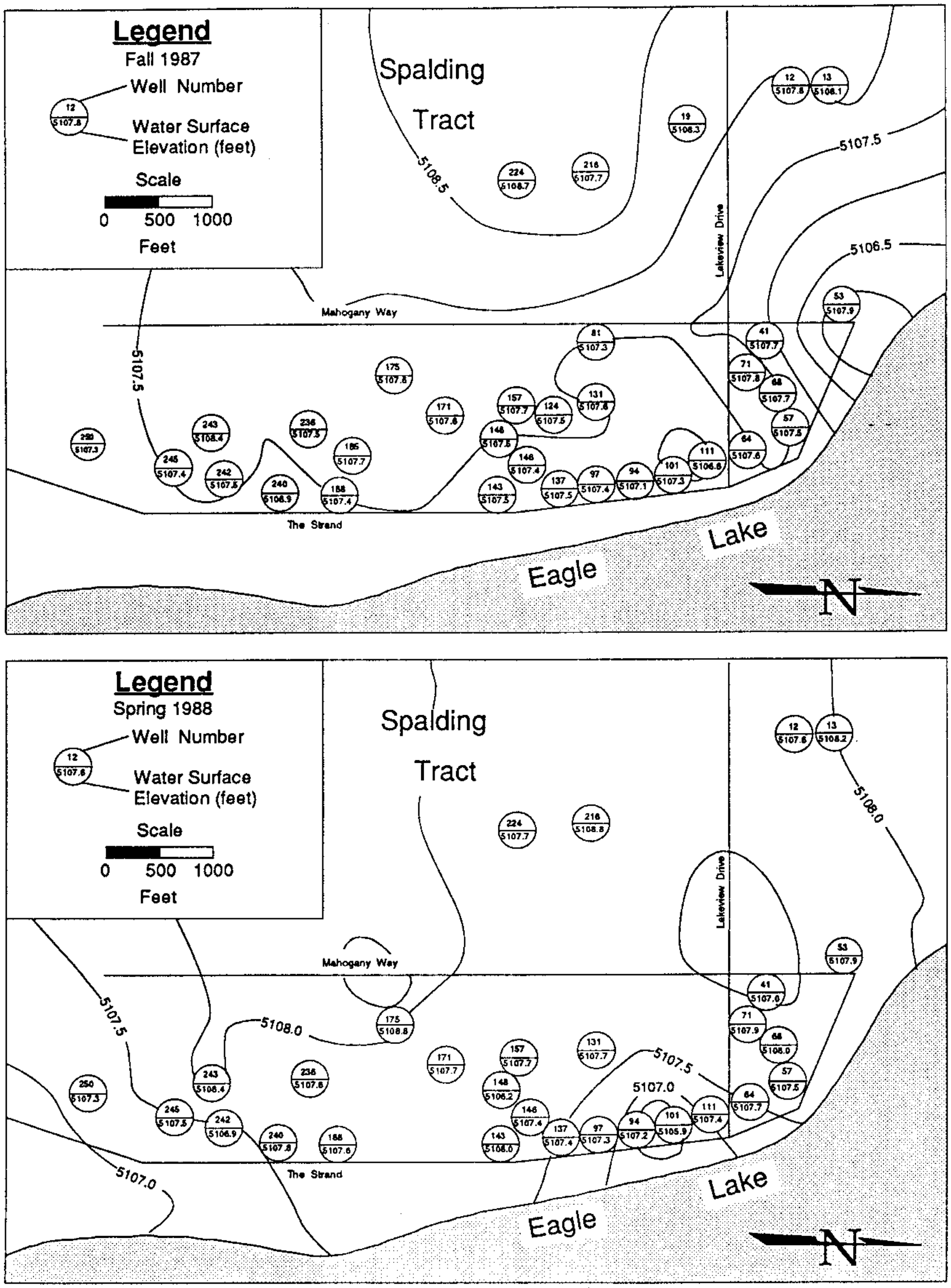


Figure 13. Fall 1987 and spring 1988 ground water levels at Spalding Tract (contours from Ruefer 1989).

plotted using data that may represent localized ground water drawdown, resulting in contours that are not representative of actual ground water flow. Except for a few measurements apparently affected by localized pumping, the difference in elevation between the upgradient and downgradient wells was about 1 foot or less during both the fall and spring, resulting in a gradient of about 0.3 feet/1,000 feet.

Contours plotted from chemical analyses from the 39 wells sampled during the fall and 32 wells sampled during the spring (Table 30) showed that concentrations of total dissolved solids (Figure 14), nitrate nitrogen (Figure 15), and ortho-phosphate phosphorus (Figure 16) tended to increase in the direction of ground water flow toward the lake. The report noted that three of the four wells with above average concentrations of total dissolved solids, nitrate nitrogen, and ortho-phosphate phosphorus are located near the lake shore. Well 53 was reported to often be turbid following windy storms on the lake, which was felt to possibly indicate a hydraulic connection between the two. Nitrate nitrogen contours were plotted, with those from the spring at slightly lesser concentrations, to demonstrate a reduction in nitrate levels, which was assumed to be due to denitrification and plant uptake. Chloride was found above the detection limit of 1 mg/L in only four wells during the fall, and one well in the spring (Figure 17). The greatest concentration detected was 3 mg/L. Three of the wells containing detectable levels of chloride are adjacent to the main road, and thus thought to be potentially affected by the use of road salts. One of the other wells with detectable chloride was the fourth well with elevated concentrations of the other parameters.

The coefficient of variation of the gravimetric method for total dissolved solids analysis is at least 10 percent at the concentrations found at Spalding Tract (APHA 1989). Differences between upgradient and downgradient wells are within the expected variation for the analysis technique. Reported concentrations of total dissolved solids are virtually identical between the fall and spring periods. Generally, a slight increase from upgradient to downgradient wells is apparent from plots of the total dissolved solids concentration at each well (Figure 14). A few wells with reported significantly greater total dissolved solids concentrations occur throughout the subdivision, but mostly near the lake. Wells FR and 53 contained the greatest total dissolved solids concentrations. Any real differences in

Table 30. Results from chemical analyses during the fall of 1987 and spring of 1988.

	TDS (mg/L)		NO3 as N (mg/L)		o-PO4 as P (mg/L)		Cl (mg/L)	
Station	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring
FR	169[1]	193	1.72	2.60	0.17	0.18	<1	1
HR	128[1]	125	0.41	0.25	0.05	0.06	<1	<1
WT	152[2]	-	0.0	-	0.13	-	<1	-
10A	123[3]	116	0.34	0.21	0.04	0.04	<1	<1
15	83[6]	92	0.30	0.29	0.06	0.05	<1	<1
17	128[4]	124	0.21	0.36	0.06	0.06	1	<1
26	132[4]	130	0.35	0.38	0.08	0.07	<1	<1
34	113[2]	125	0.41	0.26	0.05	0.05	1	<1
39	130[3]	124	0.27	0.21	0.05	0.05	3	<1
46	118[6]	-	0.32	-	0.08	-	<1	-
49	127[6]	131	0.14	0.21	0.17	0.11	<1	<1
50	126[6]	126	0.21	0.29	0.11	0.10	<1	<1
53	230[2]	238	2.44	1.17	0.76	0.40	2	<1
83	123[3]	123	0.43	0.27	0.06	0.07	<1	<1
90	130[6]	128	0.35	0.29	0.08	0.07	<1	<1
94	129[3]	-	0.56	-	0.11	-	<1	-
101	133[3]	130	0.86	0.56	0.10	0.11	<1	<1
116	131[6]	129	0.29	0.28	0.08	0.07	<1	<1
119	154[7]	151	0.05	0.04	0.10	0.08	<1	<1
123	136[4]	131	0.21	0.22	0.07	0.07	<1	<1
130	132[4]	131	0.23	0.24	0.06	0.07	<1	<1
138	143[6]	142	0.72	0.70	0.11	0.11	<1	<1
143	147[1]	139	0.32	0.18	0.08	0.08	<1	<1
146	128[5]	-	0.35	-	0.08	-	<1	-
153	130[4]	131	0.30	0.32	0.08	0.08	<1	<1
158	134[4]	-	0.42	-	0.07	-	<1	-
169	141[5]	138	0.13	0.15	0.10	0.09	<1	<1
187	131[5]	141	0.29	0.29	0.06	0.07	<1	<1
206	128[6]	-	0.27	-	0.08	-	<1	-
211	118[3]	118	0.34	0.23	0.06	0.06	<1	<1
223	135[5]	130	0.34	0.21	0.06	0.07	<1	<1
232A	119[5]	-	0.22	-	0.08	-	<1	-
237A	-	138	-	0.24	-	0.05	-	<1
238A	123[5]	138	0.31	0.26	0.07	0.07	<1	<1
242	152[1]	138	0.66	0.40	0.07	0.09	<1	<1
242A	-	138	-	0.27	-	0.07	-	<1
245A	130[8]	129	0.23	0.23	0.07	0.07	<1	<1
246	134[8]	133	0.23	0.23	0.07	0.07	<1	<1
250	132[6]	-	0.25	-	0.07	-	<1	-
253	128[6]	124	0.25	0.26	0.07	0.07	<1	<1
254	127[5]	-	0.30	-	0.08	-	<1	-
MEAN	133	135	0.42	0.38	0.10	0.09	-	-
RANGE	83-230	92-238	0.0-2.44	0.04-2.60	0.04-0.76	0.04-0.40	<1-3	<1-1

[1] 8/30/87 [2] 9/13/87 [3] 9/20/87 [4] 9/27/87 [5] 10/4/87 [6] 10/11/87 [7] 10/24/87 [8] 11/1/87

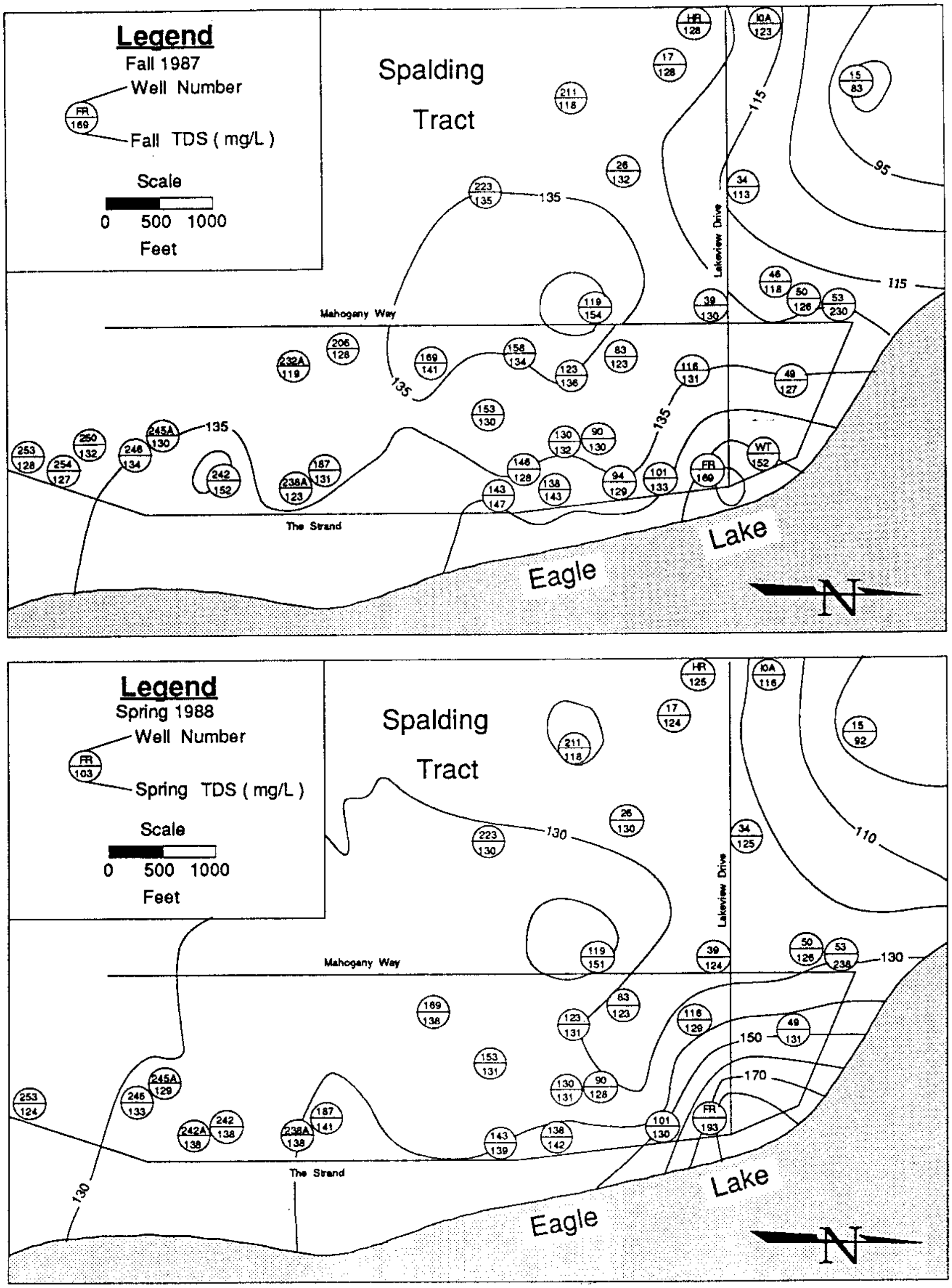


Figure 14. Fall 1987 and spring 1988 total dissolved solids concentrations at Spalding Tract (contours from Ruefer 1989).

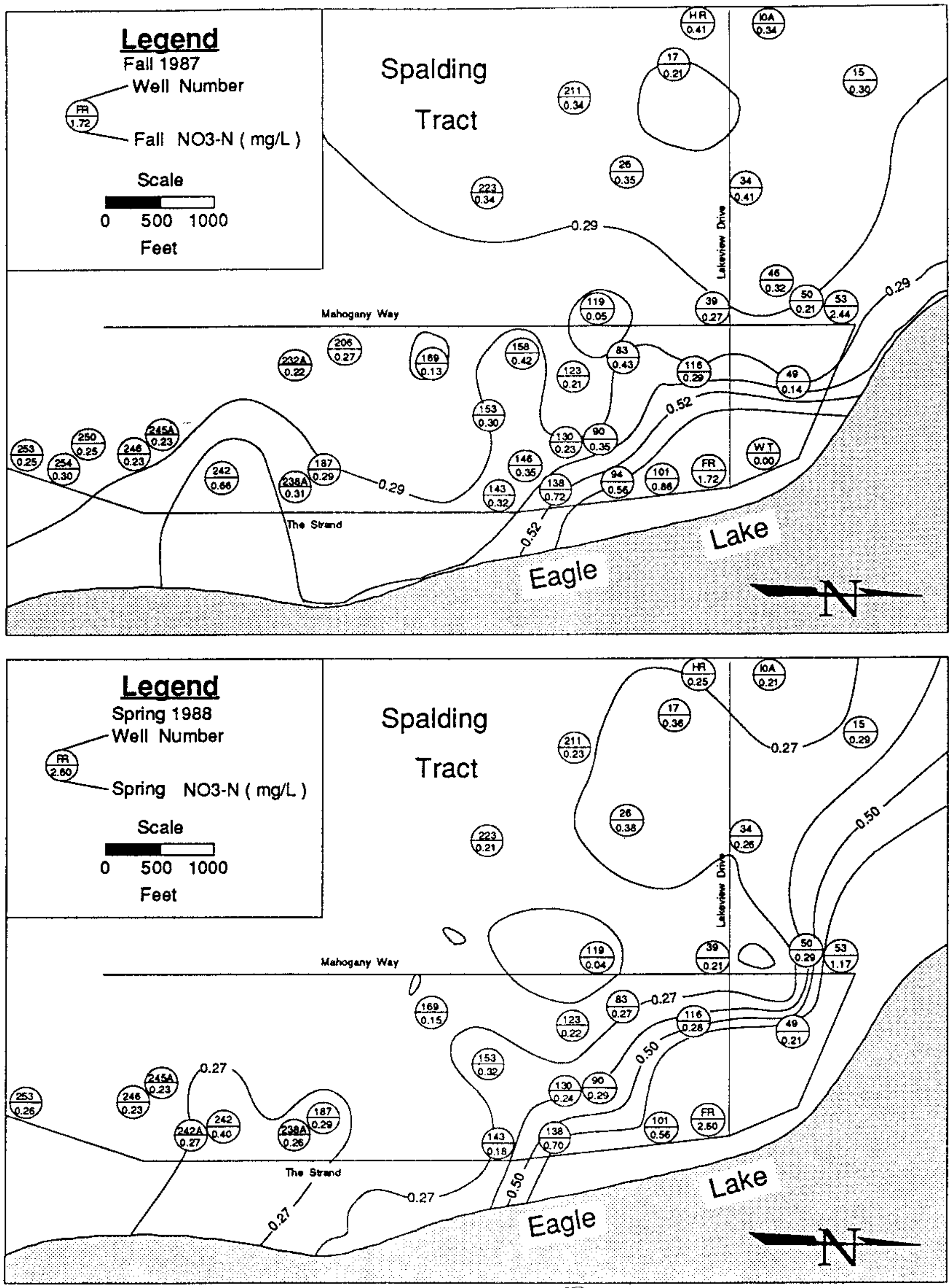


Figure 15. Fall 1987 and spring 1988 nitrate nitrogen concentrations at Spalding Tract (contours from Ruefer 1989).

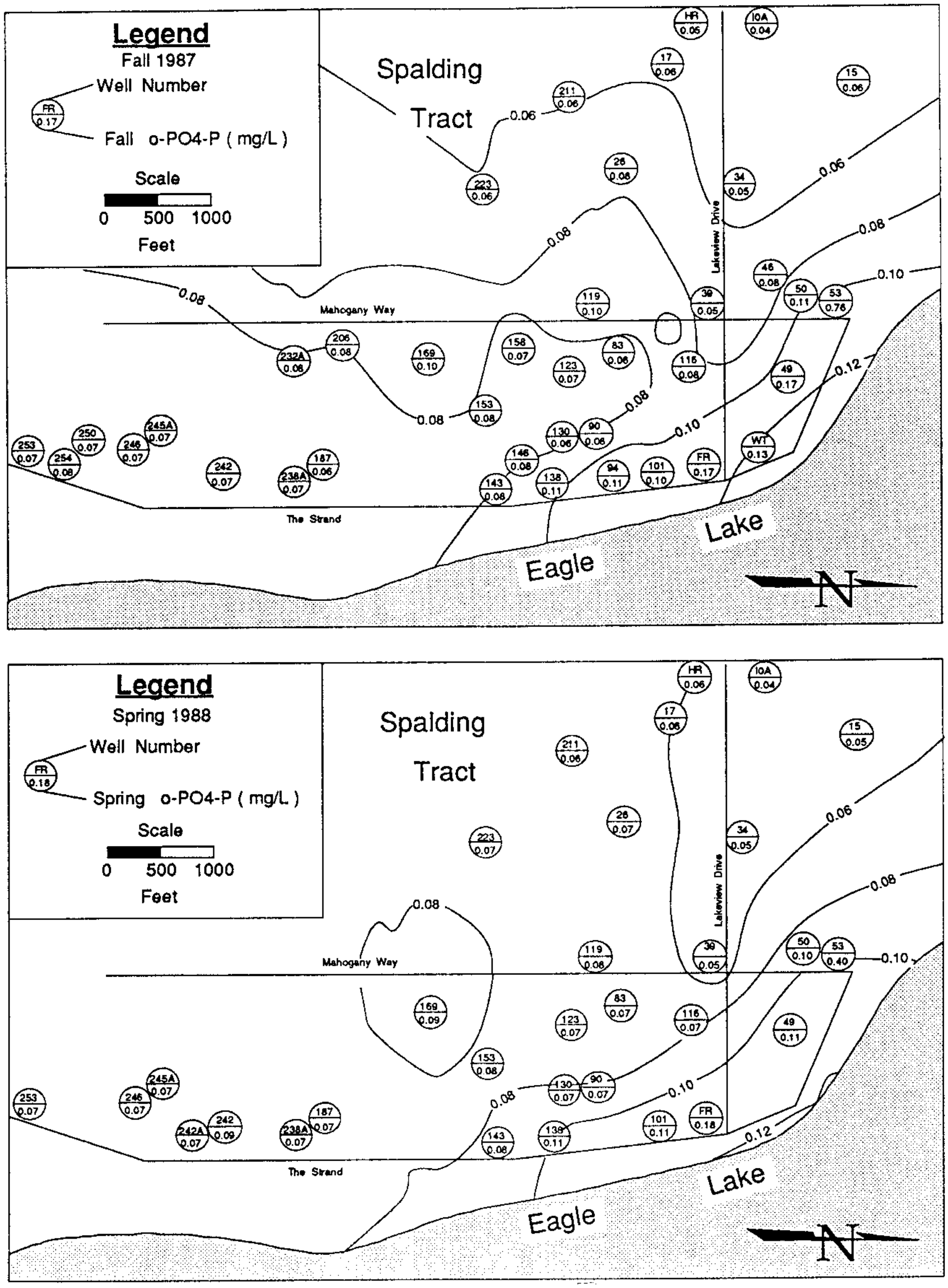


Figure 16. Fall 1987 and spring 1988 ortho-phosphate phosphorus concentrations at Spalding Tract (contours from Ruefer 1989).

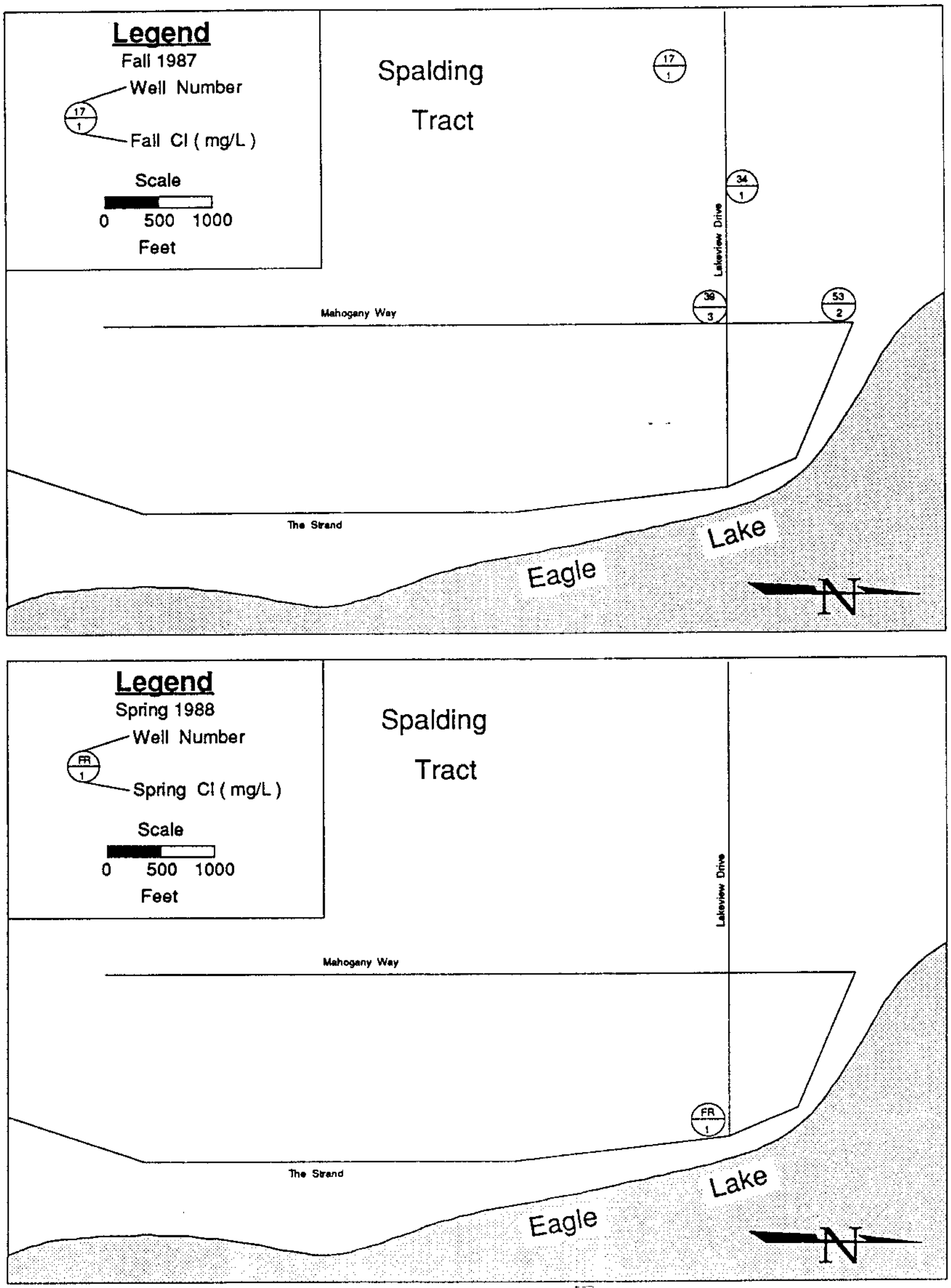


Figure 17. Fall 1987 and spring 1988 chloride monitoring results at Spalding Tract (only wells with detectable chloride shown).

concentrations of total dissolved solids between wells, such as the few high or low concentrations, could be due to differences in depths of wells or mixing of water from near the surface with deeper water due to inadequate well seals. Well logs were not reviewed.

Nitrate nitrogen was determined using the brucine method, which had been only tentatively approved (APHA 1975). The method was recommended only for the concentration range of 0.1 to 2 mg/L of nitrate nitrogen. Concentrations above this range produce anomalous results, while below this range the sensitivity of the method is poor. The ideal range for the method is 0.1 to 1 mg/L. Two wells were reported with concentrations greater than recommended for the brucine method, while one well was reported with a concentration lower than recommended. Oxidizing agents, such as residual chlorine, interfere with the brucine nitrate nitrogen determinations. Residual chlorine was not determined during the analyses. Ferrous and ferric iron, which can be expected from ground water, give slight positive interferences. The brucine method is not a currently recommended method (APHA 1989). The differences for the contours drawn for the fall and spring periods are largely artifacts of arbitrarily choosing different scales for the contours and determining where the contour line should lie between points of often widely different values. Little actual differences are apparent from plots of nitrate nitrogen concentrations throughout Spalding Tract during both the fall and spring periods (Figure 15). A few wells (FR, 53, 101, and 138) with reported significantly higher concentrations of nitrate nitrogen occur primarily near the lake. Significant differences in nitrate nitrogen concentrations between the fall and spring monitoring are not apparent. Most wells varied only slightly in nitrate nitrogen concentrations between the fall and spring periods, which may be within the precision of the analysis technique.

Ortho-phosphate phosphorus concentrations were essentially uniform throughout the subdivision, exhibiting a very slight increase from upgradient to downgradient wells, during both the fall and spring sampling periods (Figure 16). A few wells near the lake (FR, 53, 101, and 138) were reported with substantially greater concentrations.

The wells in which chloride was detected are widely scattered in the northern portion of the subdivision, including both wells FR and 53 (Figure 17). The other three wells in which chloride was detected did not contain elevated concentrations of the other parameters.

Samples were collected during the fall throughout a two month period. Significant changes in ground water quality could occur in such a time span due to underground movement of water, percolation of rainfall, and altered residency patterns. Results from the fall monitoring, therefore, are not strictly comparable among stations. Spring samples, which were collected over a time span of nearly one month, may also be subject to the same limitations. Differences in total dissolved solids, nitrate nitrogen, and ortho-phosphate phosphorus concentrations within the subdivision for either the fall or spring periods may be the result of the long time span during which samples were collected, especially during the fall. Other factors that may contribute to differences between wells include variably occurring mineral or old lacustrine deposits through which the ground water moves, differences in well depths, ground water flow patterns controlled by differences in underlying geology, surface contamination from improper well sealing, or local contamination from septic systems. Several individual wells with water quality characteristics significantly different than surrounding wells may be experiencing localized contamination. The data, however, are not sufficient to indicate sources of the higher concentrations of the various parameters in these few wells.

Sixty-four wells were sampled for bacteria (Table 31). Four wells tested positive in one of the coliform or streptococcus tests. Evidence was felt to be abundant that the source of contamination in the wells was other than septic tank effluent. The wells with bacterial contamination, *though not shown on the map of station locations*, were near the western boundary of the subdivision, thus not greatly influenced by upgradient leachfields. The well exhibiting fecal coliform bacteria (Well 209) is in a dirt floored sub-grade structure, which could be occupied by rodents and insects. One of the two wells with fecal streptococcus is above ground with a loose fitting cap, while the other is in a cement-floored above ground shed. The shed was used to store construction materials and equipment at the time of sampling. The well

Table 31. Bacteriological sampling from Spalding Tract during the fall of 1987[1,2]

Well	Total Coliform	Fecal Coliform	Fecal Streptococcus	Well	Total Coliform	Fecal Coliform	Fecal Streptococcus
FR	0	NT[3]	NT	101	NT	0	0
HR	0	NT	NT	102	NT	0	0
WT	0	NT	NT	104	NT	0	0
6	0	NT	NT	110	NT	0	0
10	NT	0	0	116	0	NT	NT
lOA	NT	0	0	123	NT	0	0
15	NT	0	0	124	NT	0	0
15A	0	NT	NT	130	NT	0	0
17	NT	0	0	130A	NT	0	0
19	0	NT	NT	136	NT	0	0
21	NT	0	0	138	NT	0	0
21A	NT	0	0	143	0	NT	NT
23	NT	0	1	146	NT	0	0
26	NT	0	0	151	NT	0	0
34	0	NT	NT	153	NT	0	0
39	NT	0	0	158	NT	0	0
41	0	NT	NT	169	NT	0	0
46	NT	0	0	187	NT	0	0
46A	0	NT	NT	206	NT	0	0
49	NT	0	0	209	NT	4	0
50	0	NT	NT	211	0	NT	NT
53	NT	0	0	213	NT	0	0
55	0	NT	NT	219	NT	0	3
66	0	NT	NT	221	1	NT	NT
68	NT	0	0	223	0	NT	NT
74	0	NT	NT	227	NT	0	0
82	NT	0	0	232A	NT	0	0
83	NT	0	0	238A	NT	0	0
85	NT	0	0	242	0	NT	NT
90	NT	0	0	250	NT	0	0
90A	NT	0	0	253	NT	0	0
94	NT	0	0	254	NT	0	0

[1] Number of bacteria per 100 mL of sample
[2] Membrane Filter Technique
[3] Not tested

with total coliform bacteria (Well 221) is above ground in a shed. The total coliform bacteria were thought to be due to a variety of factors, including insects or soil, but not septic tank effluent since the bacterial level was low.

The maximum holding time for bacterial samples used in legal action is 6 hours (APHA 1989, Federal Register 1979). Transport difficulties encountered in remote

field studies make such short holding periods unrealistic for routine monitoring. The recommended maximum holding time for routine monitoring, therefore, is 24 hours (APHA 1989). The time that elapses between collection of samples and analyses should be considered in interpretation of the data, since significant changes could occur with delayed analyses. Bacterial samples were held up to 30 hours before analysis. Some loss of viable organisms could have occurred.

Only 19 of the 64 wells were sampled for total coliform. Fecal coliform and fecal streptococcus analyses were conducted on the remaining 45 wells, but not the 19 for which total coliform bacteria were sampled. The three wells with fecal coliform or streptococcus contamination could have also tested positive for total coliform organisms. Some of the 45 wells that tested negative for fecal coliform and streptococcus may also have produced positive results for total coliform bacteria had that test been conducted. Any changes in microbial composition associated with holding times of up to 30 hours cannot be determined. Since species of bacteria were not determined, the source of the bacteria cannot be determined, nor can septic tank effluent be eliminated as a possible source. Any level of bacterial contamination in a well is a potential health hazard.

DEPARTMENT OF WATER RESOURCES STUDY

In 1989, following review of the existing data for Spalding Tract, the Department of Water Resources and Department of Health Services began field and laboratory studies to determine potential contamination from septic tank effluent.

Methods

A monitoring grid of 52 water wells was established throughout the Spalding Tract subdivision. Water well drillers logs that had been filed with the Department of Water Resources were reviewed to establish potential monitoring wells. The logs were reviewed for well location, depth, construction, and suitability of seal. Wells potentially suitable for monitoring were then visited to determine accessability and to obtain permission to sample. Where wells lacked access (such as inoperative wells with no pump and welded caps) or permission to sample could not be obtained, nearby wells were field checked as potential monitoring sites. Only wells for which well logs could be located and which were reasonably constructed were used for the monitoring grid. Any potential problems with construction of wells selected for monitoring were noted.

The surface elevation of each well, in reference to the U. S. Geological Survey benchmark at the Spalding Tract landing strip, was determined by surveying in early October 1989. The elevation of Eagle Lake was determined from the Department of Water Resources gage on Pine Creek and checked by survey. Depth to water in each well was measured with a chalked steel tape during the last week in both September 1989 and May 1990. The depth to water measurements were then used to calculate the water surface elevations in each well during the fall and spring periods.

Wells were sampled in September 1989 and May 1990 for chemical and bacteriological analyses, and determination of depth to water. Additional samples for bacteriological analyses were collected in October and December of 1989 from wells that had shown high contamination. Water was collected from an outside tap closest to the well in clean and sterilized plastic bottles supplied by the Department of Health Services. Prior to collection of the water sample, the tap was allowed to

run at least 10 minutes, which was calculated to be sufficient to purge both pressure tank and well casing. Water was often discharged through a garden hose away from the well or residence to avoid creating a muddy nuisance for the property owner. Prior to sample collection, water from the tap or hose was measured periodically for temperature, pH, and electrical conductivity to insure that aquifer water was being drawn rather than water standing in the pressure tank or well casing. The well water was also tested for residual chlorine. When two or more measurements produced identical temperature, pH, and electrical conductivity readings, the hose was disconnected, where used, and samples were collected directly from the tap for chemical and bacteriological analyses. Replicate samples for both chemical and bacteriological analyses were collected in September 1989. Replicate samples were collected in May 1990 only for bacteriological analyses.

Samples collected in 1989 were transported to the Department of Health Services laboratory in Berkeley via Greyhound bus within 24 hours after collection. Refrigerated samples were transported each evening to Redding by field crew for overnight delivery to the Department of Health Services. Samples for bacteriological analyses in May 1990 were delivered within two to three hours after collection to the Department of Health Services Mobile Laboratory stationed at Spalding Tract for on-site analyses. Samples for chemical analyses were collected following the bacteriological sampling, and transported by car within 24 hours to the Berkeley laboratory. Analyses for electrical conductivity, alkalinity, and turbidity were conducted from samples at the laboratory of the Department of Water Resources in Red Bluff.

Water samples were analyzed at the Department of Health Services laboratory for total dissolved solids, nitrate nitrogen, ortho-phosphate phosphorus, chloride, total coliform, fecal coliform, and fecal streptococcus. Additional analyses were conducted in May for bacterial speciation. The ascorbic acid method (Method 365.3) was used for ortho-phosphate phosphorus determinations (EPA 1979). Total dissolved solids were analyzed by evaporation according to APHA Method 2540 C (APHA 1989). The automated cadmium reduction method (APHA Method 4500-NO_3^- F) was used for nitrate nitrogen determinations, while the mercuric nitrate method (APHA Method 4500-Cl^- C) was used for chloride determinations. Most

probable number coliform and streptococcus bacteria counts were determined with the standard total coliform multiple-tube (MPN) fermentation technique (APHA Method 9221 B), fecal coliform MPN procedure (APHA Method 9221 C), and fecal streptococcus multiple-tube technique (APHA Method 9230 B). During May, total and fecal coliform bacteria were also determined with the standard total coliform membrane filter procedure (APHA Method 9222 B) and fecal coliform membrane filter procedure (APHA Method 9222 D). The enzymatic substrate coliform test (Colilert MPN) of Access Analytical Systems was used for total coliform (in addition to *E. coli,*) comparisons with the other methods to evaluate this new technique. Positive confirmatory tubes and colonies growing on Pfizer selective enterococcus (PSE) agar (APHA Method 9230 B) were subcultured to obtain pure cultures for species identification on Analytical Profile Index kits 20E and S.

Results

Though ground water would be expected to flow toward Eagle Lake, the ground water table was essentially flat during both the fall 1989 (Figure 18) and spring 1990 (Figure 19) measurements. The water surface elevation ranged from 5,102.6 to 5,104.4 feet during the fall, and 5,102.5 to 5,104.4 feet during the spring. Most differences in water elevations reflect localized ground water pumping rather than ground water gradients in the subdivision. Most wells exhibited a decline of a few tenths of a foot in water surface elevation from the fall to spring measurements. Eagle Lake had a surface elevation of 5,103.6 feet in the fall of 1989 and 5,103.4 feet in the spring of 1990. Water levels in wells near the lake were at the same elevation as the lake.

Laboratory total dissolved solids analyses of replicate fall samples produced widely varying results (Table 32). Many of the reported results are not within the acceptable criteria range (0.55 to 0.7) for the total dissolved solids to electrical conductivity ratio (APHA 1989). These results are considered suspect, and, therefore, are not used for ground water analyses at Spalding Tract. Total dissolved solids were not analyzed during the spring.

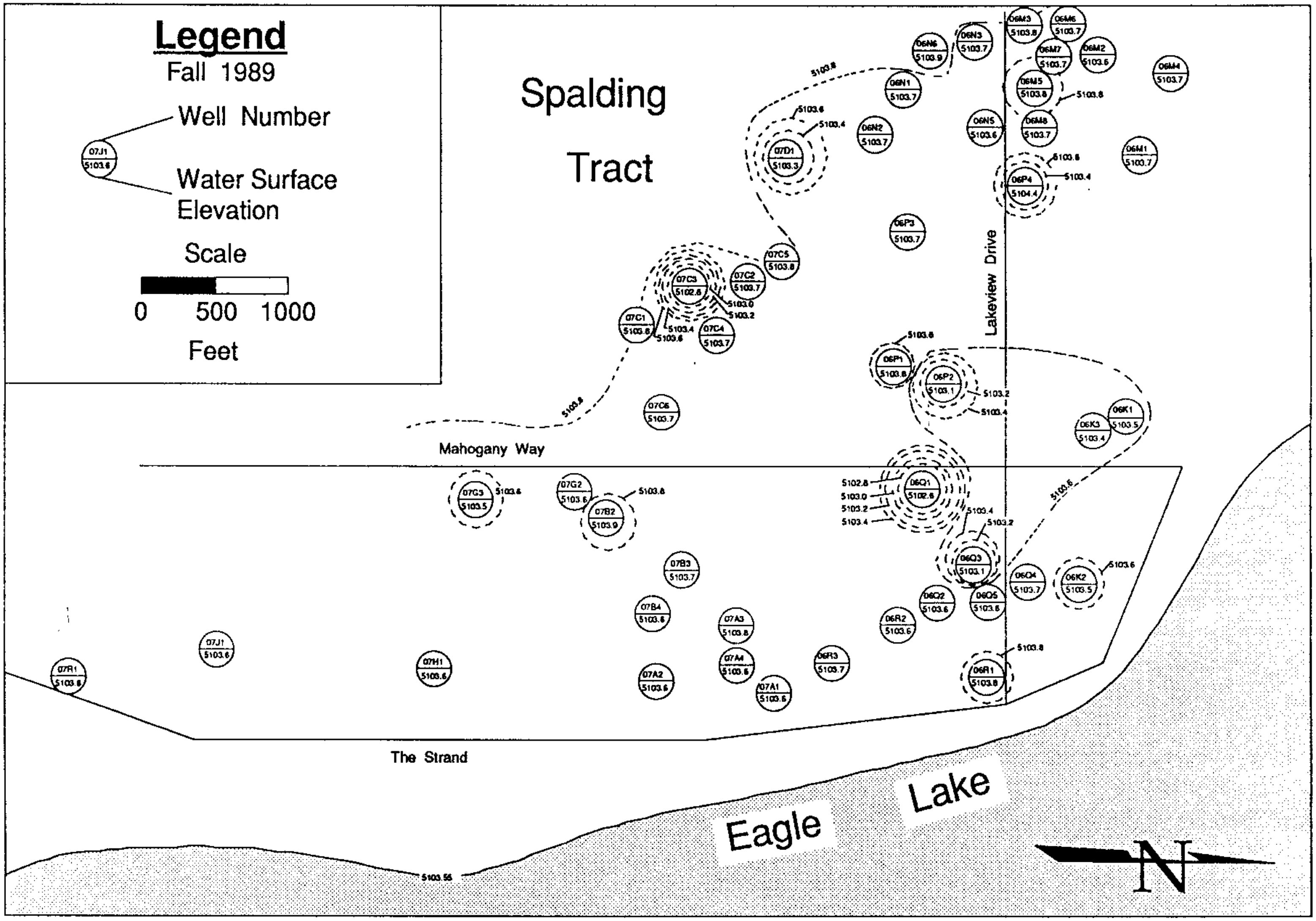


Figure 18. Ground water level contours at Spalding Tract for fall 1989 (contour intervals are 0.2 feet).

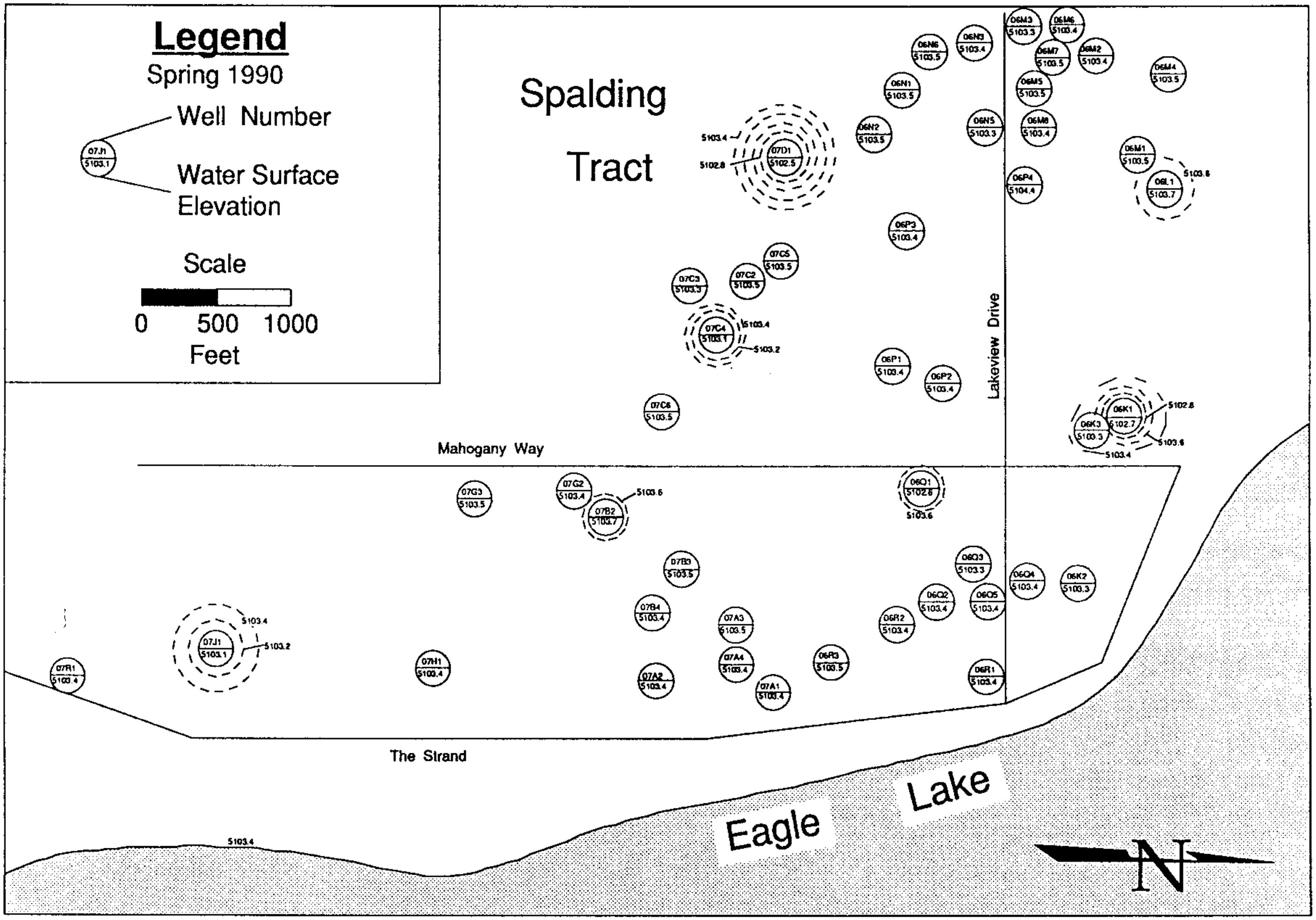


Figure 19. Ground water level contours at Spalding Tract for spring 1990 (contour intervals are 0.2 feet).

Table 32. Field and laboratory results from Spalding Tract during the fall of 1989 and spring of 1990.

Well Number	Date	Time (PST)	Ground Elev. (ft)	Water Surface Elev. (ft)	Water Depth (ft)	Temp. (F)	pH	Electrical Conductivity (umhos/cm) Field	Electrical Conductivity (umhos/cm) Lab	Alkalinity (mg/L as CaCO3)	Turb. (NTU)	Bacteriological: Multiple Tube (MPN) TC	Multiple Tube (MPN) FC	Multiple Tube (MPN) FS	Colilert (MPN) TC	Colilert (MPN) *E. coli*	Membrane Filter TC	Membrane Filter FC	Chemical Analyses (mg/L) TDS	NO3-N	PO4-P	Cl
06K1	09/26/89	0855	5,137.5	5,103.5	34.0	53	7.1	200	201	98	0.3	<2.2	<2.2	<2.2	-	-	-	-	114	0.29	0.09	1.2
-	09/27/89	1315	-	-	-	55	7.1	199	202	97	0.3	2.2	<2.2	<2.2	-	-	-	-	131	0.26	0.11	1.2
-	05/21/90	1045	-	-	-	52	7.1	196	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/22/90	0910	-	-	-	52	7.1	196	-	-	-	<2.2	<2.2	<2.2	5.1	<2.2	<1	<1	-	-	-	-
-	05/23/90	1000	5,137.5	5,102.7	34.8	51	7.1	201	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/29/90	0815	-	-	-	53	7.1	200	211	105	0.5	-	-	-	-	-	-	-	-	0.27	-	1.2
06K2	09/26/89	0915	5,129.4	5,103.5	25.9	52	7.1	204	204	111	0.6	<2.2	<2.2	<2.2	-	-	-	-	92	0.37	0.1	1.2
-	09/27/89	1340	-	-	-	52	7.1	203	204	111	0.5	<2.2	<2.2	<2.2	-	-	-	-	163	0.36	0.12	1.2
-	05/21/90	1055	-	-	-	52	7.1	199	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/22/90	0925	-	-	-	52	7.1	199	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/23/90	-	5,129.4	5,103.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	05/29/90	0840	-	-	-	53	7.0	199	213	105	1.1	-	-	-	-	-	-	-	-	0.43	-	1.2
06K3	09/26/89	0930	5,137.4	5,103.4	34.0	53	7.1	206	203	117	0.2	<2.2	<2.2	<2.2	-	-	-	-	80	0.28	0.1	1.2
-	09/27/89	1250	-	-	-	54	6.9	206	204	112	0.3	<2.2	<2.2	<2.2	-	-	-	-	109	0.26	0.13	1.2
-	05/21/90	1030	-	-	-	53	7.1	202	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/22/90	0800	-	-	-	53	7.1	202	-	-	-	<2.2	<2.2	<2.2	5.1	<2.2	<1	<1	-	-	-	-
-	05/23/90	-	5,137.4	5,103.3	34.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	05/24/90	1240	-	-	-	53	7.1	202	-	-	-	<2.2	<2.2	2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/29/90	0815	-	-	-	53	7.1	202	214	107	0.5	-	-	-	-	-	-	-	-	0.25	-	1.2
06L1	09/25/89	1410	-	-	-	53	6.9	148	160	73	0.3	<2.2	<2.2	<2.2	-	-	-	-	165	0.56	0.07	1.5
-	09/27/89	0855	-	-	-	53	6.9	159	160	80	2.7	<2.2	<2.2	<2.2	-	-	-	-	165	0.50	0.13	1.2
-	05/21/90	1045	-	-	-	53	6.9	162	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/22/90	1045	-	-	-	53	6.7	162	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/23/90	-	5,146.6	5,103.7	42.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	05/24/90	-	-	-	-	-	-	-	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/29/90	0840	-	-	-	52	6.7	162	161	75	0.3	-	-	-	-	-	-	-	-	0.52	-	1.6
06M1	09/25/89	1435	5,146.8	5,103.7	43.1	52	6.7	134	145	69	0.3	<2.2	<2.2	<2.2	-	-	-	-	166	0.23	0.05	1.3
-	09/27/89	0915	-	-	-	52	6.7	144	145	77	0.4	<2.2	<2.2	<2.2	-	-	-	-	144	0.27	0.08	1.2
-	05/21/90	1020	-	-	-	51	6.7	155	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/22/90	1025	-	-	-	51	6.7	155	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/23/90	-	5,146.8	5,103.5	43.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	05/24/90	-	-	-	-	-	-	-	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/29/90	0820	-	-	-	50	6.7	152	150	60	0.5	-	-	-	-	-	-	-	-	0.27	-	1.2

Table 32. Field and laboratory results from Spalding Tract during the fall of 1989 and spring of 1990.

Well Number	Date	Time (PST)	Ground Elev. (ft)	Water Surface Elev. (ft)	Water Depth (ft)	Temp. (F)	pH	Electrical Conductivity (umhos/cm) Field	Lab	Alkalinity (mg/L as CaCO3)	Turb. (NTU)	Bacteriological: Multiple Tube (MPN) TC	FC	FS	Colilert (MPN) TC	*E. coli*	Membrane Filter TC	FC	Chemical Analyses (mg/L) TDS	NO3-N	PO4-P	Cl
06M2	09/25/89	1505	5,147.2	5,103.6	43.6	56	6.9	167	170	83	0.3	<2.2	<2.2	<2.2	-	-	-	-	120	0.23	0.06	1.2
-	09/27/89	0945	-	-	-	56	6.9	173	169	81	0.3	<2.2	<2.2	<2.2	-	-	-	-	131	0.23	0.07	1.2
-	05/21/90	1115	-	-	-	54	6.9	180	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/22/90	1155	-	-	-	55	6.7	176	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/24/90	-	5,147.2	5,103.4	43.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	05/29/90	0850	-	-	-	55	6.7	178	174	85	0.3	-	-	-	-	-	-	-	-	0.25	-	1.2
06M3	09/25/89	1610	5,149.9	5,103.8	46.1	58	6.9	175	177	93	0.3	<2.2	<2.2	<2.2	-	-	-	-	153	0.22	0.06	1.2
-	09/27/89	1035	-	-	-	58	7.1	179	177	86	0.3	<2.2	<2.2	<2.2	-	-	-	-	110	0.24	0.08	0.9
-	05/21/90	1230	-	-	-	56	6.9	187	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/22/90	1200	-	-	-	57	7.0	186	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/24/90	-	5,149.9	5,103.3	46.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	05/29/90	0930	-	-	-	56	7.0	186	183	81	0.3	-	-	-	-	-	-	-	-	0.27	-	1.2
06M4	09/25/89	1320	-	-	-	50	6.9	123	132	44	0.9	<2.2	<2.2	<2.2	-	-	-	-	187	0.22	0.06	1.5
-	09/27/89	0820	5,146.0	5,103.7	42.3	52	6.9	130	133	63	1	<2.2	<2.2	<2.2	-	-	-	-	145	0.21	0.06	1.2
-	05/21/90	1000	-	-	-	50	6.9	124	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/22/90	1000	-	-	-	50	6.7	131	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/23/90	-	5,146.0	5,103.5	42.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	05/24/90	-	-	-	-	-	-	-	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/29/90	0800	-	-	-	50	6.7	132	129	61	0.8	-	-	-	-	-	-	-	-	0.20	-	1.2
06M5	09/25/89	1640	5,146.9	5,103.8	43.1	56	6.9	169	172	73	0.3	<2.2	<2.2	<2.2	-	-	-	-	165	0.21	0.06	1.2
-	09/27/89	1050	-	-	-	58	6.9	177	174	91	0.3	<2.2	<2.2	<2.2	-	-	-	-	164	0.23	0.07	1.2
-	05/21/90	1245	-	-	-	55	6.9	182	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/22/90	1220	-	-	-	55	7.0	180	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/24/90	-	5,146.9	5,103.5	43.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	05/29/90	0950	-	-	-	55	7.0	180	177	89	0.4	-	-	-	-	-	-	-	-	0.25	-	1.2
06M6	09/25/89	1530	5,147.5	5,103.7	43.8	59	6.9	167	173	87	0.4	5.1	<2.2	5.1	-	-	-	-	142	0.21	0.08	1.2
-	09/27/89	0955	-	-	-	58	6.9	178	173	97	0.4	<2.2	<2.2	<2.2	-	-	-	-	166	0.23	0.07	1.2
-	10/10/89	1035	-	-	-	56	7.1	178	-	-	-	<2.2	<2.2	<2.2	-	-	-	-	-	-	-	-
-	05/21/90	1130	-	-	-	56	6.9	185	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/22/90	1140	5,147.5	5,103.4	44.1	56	7.1	183	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/23/90	1215	-	-	-	54	7.1	189	-	-	-	<2	<2	<2.2	<2	<2	<1	<1	-	-	-	-
-	05/24/90	1415	-	-	-	54	7.1	184	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/29/90	0915	-	-	-	55	7.0	184	180	90	0.5	-	-	-	-	-	-	-	-	0.27	-	1.2

Table 32. Field and laboratory results from Spalding Tract during the fall of 1989 and spring of 1990.

Well Number	Date	Time (PST)	Ground Elev. (ft)	Water Surface Elev. (ft)	Water Depth (ft)	Temp. (F)	pH	Electrical Conductivity (umhos/cm)		Alkalinity (mg/L as CaCO3)	Turb. (NTU)	Bacteriological							Chemical Analyses (mg/L)			
												Multiple Tube (MPN)			Colilert (MPN)		Membrane Filter					
								Field	Lab			TC	FC	FS	TC	E. coli	TC	FC	TDS	NO3-N	PO4-P	Cl
06M7	09/25/89	1545	5,147.5	5,103.7	43.8	56	6.9	168	174	94	0.3	<2.2	<2.2	<2.2	-	-	-	-	154	0.22	0.05	1.2
-	09/27/89	1010	-	-	-	56	6.9	179	176	87	0.3	<2.2	<2.2	<2.2	-	-	-	-	175	0.22	0.08	1.2
-	05/21/90	1150	-	-	-	54	6.9	184	-	-	-	>16	<2.2	<2.2	>16	<2.2	40	<1	-	-	-	-
-	05/22/90	1125	-	-	-	56	6.7	182	-	-	-	8	<2	<2.2	2.2	<2.2	14	<1	-	-	-	-
-	05/23/90	1215	-	-	-	55	7.0	189	-	-	-	4	<2	<2.2	<2	<2	<1	<1	-	-	-	-
-	05/24/90	1415	5,147.5	5,103.5	44.0	56	7.1	184	-	-	-	8	<2	<2	<2.2	<2.2	5	<1	-	-	-	-
-	05/29/90	0900	-	-	-	55	7.0	184	179	86	0.3	-	-	-	-	-	-	-	-	0.27	-	1.2
06M8	09/26/89	0910	5,146.7	5,103.7	43.0	55	6.9	170	164	86	0.4	<2.2	<2.2	<2.2	-	-	-	-	118	0.23	0.06	1.2
-	09/27/89	1115	-	-	-	56	6.9	165	164	79	0.4	<2.2	<2.2	<2.2	-	-	-	-	174	0.22	0.07	1.2
-	05/21/90	1310	-	-	-	54	6.9	175	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/22/90	1245	-	-	-	54	6.9	175	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/24/90	-	5,146.7	5,103.4	43.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	05/29/90	1025	-	-	-	54	7.0	172	170	82	0.3	-	-	-	-	-	-	-	-	0.27	-	1.2
06N1	09/26/89	1220	5,145.7	5,103.7	42.0	59	7.3	198	193	101	0.4	5.1	<2.2	<2.2	-	-	-	-	170	1.4	0.08	1.7
-	09/27/89	1450	-	-	-	59	7.1	189	193	100	0.3	2.2	<2.2	<2.2	-	-	-	-	100	0.31	0.09	1.2
-	05/21/90	1545	-	-	-	54	7.1	206	-	-	-	16	<2.2	<2.2	5.1	<2.2	<1	<1	-	-	-	-
-	05/22/90	1515	-	-	-	54	7.1	205	-	-	-	13	<2	<2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/23/90	1300	-	-	-	54	7.1	207	-	-	-	8	<2	<2.2	<2	<2	<1	<1	-	-	-	-
-	05/24/90	1250	5,145.7	5,103.5	42.2	55	7.2	203	-	-	-	2.2	<2.2	<2.2	16	<2.2	<1	<1	-	-	-	-
-	05/29/90	1115	-	-	-	55	7.2	202	199	89	0.3	-	-	-	-	-	-	-	-	0.38	-	1.2
06N2	09/26/89	1245	5,147.2	5,103.7	43.5	58	7.3	199	194	106	0.4	2.2	<2.2	<2.2	-	-	-	-	226	0.26	0.08	0.9
-	09/27/89	1515	-	-	-	60	7.3	189	195	95	0.4	<2.2	<2.2	<2.2	-	-	-	-	121	0.26	0.08	0.9
-	05/24/90	1310	5,147.2	5,103.5	43.7	56	7.3	202	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/25/90	0915	-	-	-	55	7.3	203	-	-	-	-	-	-	-	-	<1	<1	-	-	-	-
-	05/29/90	1210	-	-	-	56	7.4	201	200	99	0.5	-	-	-	-	-	-	-	-	0.25	-	1.2
06N3	09/26/89	0940	5,147.0	5,103.7	43.3	58	7.3	194	188	98	0.3	<2.2	<2.2	<2.2	-	-	-	-	106	0.23	0.08	1.2
-	09/27/89	1245	-	-	-	59	7.3	182	188	93	0.3	<2.2	<2.2	<2.2	-	-	-	-	101	0.21	0.07	1.2
-	05/21/90	1415	-	-	-	57	7.0	197	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/22/90	1350	-	-	-	57	7.3	197	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/24/90	-	5,147.0	5,103.4	43.6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	05/29/90	1045	-	-	-	56	7.1	195	191	90	0.2	-	-	-	-	-	-	-	-	0.36	-	1.8
06N4	09/26/89	1310	5,146.6	-	-	58	7.3	200	196	92	0.3	>16	>16	2.2	-	-	-	-	238	0.44	0.1	1.7
-	09/27/89	1530	-	-	-	59	7.3	192	197	106	0.3	>16	16	<2.2	-	-	-	-	166	0.44	0.09	1.2
-	05/24/90	1330	-	-	-	56	7.3	198	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/25/90	1000	-	-	-	56	7.3	203	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	05/29/90	1230	-	-	-	55	7.4	200	197	91	0.3	-	-	-	-	-	<1	<1	-	0.27	-	1.5

Table 32. Field and laboratory results from Spalding Tract during the fall of 1989 and spring of 1990.

Well Number	Date	Time (PST)	Ground Elev. (ft)	Water Surface Elev. (ft)	Water Depth (ft)	Temp. (F)	pH	Electrical Conductivity (umhos/cm) Field	Electrical Conductivity (umhos/cm) Lab	Alkalinity (mg/L as CaCO3)	Turb. (NTU)	Bacteriological: Multiple Tube (MPN) TC	Multiple Tube (MPN) FC	Multiple Tube (MPN) FS	Colilert (MPN) TC	Colilert (MPN) E. coli	Membrane Filter TC	Membrane Filter FC	Chemical Analyses (mg/L): TDS	NO3-N	PO4-P	Cl
06N5	09/25/89	1700	5,147.7	5,103.6	44.1	57	6.9	174	176	85	0.3	<2.2	<2.2	<2.2	-	-	-	-	116	0.21	0.07	1.2
-	09/27/89	1210	-	-	-	58	6.9	177	187	98	0.3	<2.2	<2.2	<2.2	-	-	-	-	121	0.23	0.1	1.2
-	05/21/90	1400	-	-	-	55	6.9	189	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/22/90	1340	-	-	-	56	6.9	189	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/23/90	-	5,147.7	5,103.3	44.4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	05/29/90	1035	-	-	-	56	7.0	186	183	86	0.3	-	-	-	-	-	-	-	-	0.27	-	0.9
06N6	09/26/89	1140	5,149.6	5,103.9	45.7	58	7.3	196	189	93	0.4	<2.2	<2.2	<2.2	-	-	-	-	96	0.28	0.09	1.2
-	09/27/89	1430	-	-	-	60	7.1	186	189	97	0.3	>16	>16	>16	-	-	-	-	134	0.22	0.08	1.2
-	10/10/89	1110	-	-	-	59	7.1	194	-	-	-	50	8	80	-	-	-	-	-	-	-	-
-	10/10/89	1110	-	-	-	59	7.1	194	-	-	-	130	13	50	-	-	-	-	-	-	-	-
-	12/04/89	-	-	-	-	-	-	-	-	-	-	<2	<2	<2	-	-	-	-	-	-	-	-
-	12/04/89	-	-	-	-	-	-	-	-	-	-	2	<2	<2	-	-	-	-	-	-	-	-
-	05/22/90	0715	-	-	-	57	7.1	202	-	-	-	2	<2	<2	4	<2	<1	<1	-	-	-	-
-	05/22/90	1500	-	-	-	57	7.2	201	-	-	-	2	<2	2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/23/90	1245	-	-	-	56	7.2	202	-	-	-	2.2	<2.2	<2.2	<2	<2	<1	<1	-	-	-	-
-	05/24/90	1400	5,149.6	5,103.5	46.1	57	7.2	199	-	-	-	<2	2	<2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/29/90	1100	-	-	-	57	7.3	198	194	93	0.3	-	-	-	-	-	-	-	-	0.25	-	0.9
06P1	09/26/89	1050	5,151.5	5,103.8	47.7	56	7.1	195	189	98	1.3	<2.2	<2.2	2.2	-	-	-	-	157	0.28	0.09	1.2
-	09/27/89	1330	-	-	-	57	7.1	185	189	103	0.4	<2.2	<2.2	<2.2	-	-	-	-	56	0.28	0.08	1.2
-	05/21/90	1500	-	-	-	55	7.1	200	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/22/90	1440	-	-	-	56	7.2	199	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/24/90	-	5,151.5	5,103.4	48.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	05/29/90	1145	-	-	-	55	7.2	196	191	88	1.5	-	-	-	-	-	-	-	-	0.27	-	1.5
06P2	09/26/89	1020	5,151.5	5,103.1	48.4	57	7.1	199	191	104	0.2	<2.2	<2.2	<2.2	-	-	-	-	96	0.26	0.11	1.2
-	09/27/89	1315	-	-	-	57	7.1	187	190	93	0.2	2.2	<2.2	<2.2	-	-	-	-	123	0.24	0.08	1.2
-	05/21/90	1440	-	-	-	55	7.1	204	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/22/90	1405	5,151.5	5,103.4	48.1	54	7.2	202	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/29/90	1130	-	-	-	55	7.2	200	196	86	0.2	-	-	-	-	-	-	-	-	0.23	-	1.2
06P3	09/27/89	1400	5,144.2	5,103.7	40.5	57	7.1	192	198	98	0.3	5.1	<2.2	<2.2	-	-	-	-	111	0.56	0.08	1.2
-	09/28/89	0815	-	-	-	55	7.0	198	196	83	0.3	<2.2	<2.2	<2.2	-	-	-	-	134	0.53	0.08	1.2
-	05/21/90	1520	-	-	-	50	7.1	207	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/22/90	1420	-	-	-	55	7.1	206	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/24/90	-	5,144.2	5,103.4	40.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	05/29/90	1200	-	-	-	54	7.2	204	200	90	1.1	-	-	-	-	-	-	-	-	0.50	-	1.5

Table 32. Field and laboratory results from Spalding Tract during the fall of 1989 and spring of 1990.

Well Number	Date	Time (PST)	Ground Elev. (ft)	Water Surface Elev. (ft)	Water Depth (ft)	Temp. (F)	pH	Electrical Conductivity (umhos/cm) Field	Electrical Conductivity (umhos/cm) Lab	Alkalinity (mg/L as CaCO3)	Turb. (NTU)	Bacteriological: Multiple Tube (MPN) TC	Multiple Tube (MPN) FC	Multiple Tube (MPN) FS	Colilert (MPN) TC	Colilert (MPN) E. coli	Membrane Filter TC	Membrane Filter FC	Chemical Analyses (mg/L) TDS	NO3-N	PO4-P	Cl
06P4	09/26/89	0825	-	-	-	56	6.9	185	176	81	0.2	<2.2	<2.2	<2.2	-	-	-	-	78	0.26	0.07	1.2
-	09/27/89	1145	5,151.7	5,104.4	47.3	56	6.9	180	187	91	0.3	<2.2	<2.2	<2.2	-	-	-	-	120	0.25	0.07	1.2
-	05/21/90	1330	-	-	-	55	6.9	191	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/22/90	1320	-	-	-	55	6.9	190	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/24/90	-	5,151.7	5,104.4	47.3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	05/29/90	1010	-	-	-	55	7.0	189	185	87	0.2	-	-	-	-	-	-	-	-	0.32	-	1.2
06Q1	09/26/89	1115	5,139.2	5,102.6	36.6	55	7.1	186	189	90	0.2	<2.2	<2.2	<2.2	-	-	-	-	100	0.28	0.07	1.2
-	09/27/89	1535	-	-	-	56	7.1	193	190	102	0.2	<2.2	<2.2	<2.2	-	-	-	-	113	0.32	0.1	1.2
-	05/21/90	1155	-	-	-	53	6.9	187	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/22/90	1030	5,139.2	5,102.6	36.6	54	7.0	185	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/29/90	0930	-	-	-	54	6.9	184	-	-	-	-	-	-	-	-	-	-	-	0.25	-	0.9
06Q2	09/26/89	1150	5,132.2	5,103.6	28.6	55	7.1	193	199	89	0.7	<2.2	<2.2	<2.2	-	-	-	-	143	0.32	0.09	0.9
-	09/27/89	1600	-	-	-	54	6.9	200	198	103	0.4	<2.2	<2.2	<2.2	-	-	-	-	173	0.30	0.12	1.2
-	05/21/90	1300	-	-	-	53	7.0	190	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/22/90	1040	-	-	-	53	7.1	189	-	-	-	<2.2	<2.2	<2.2	5.1	<2.2	<1	<1	-	-	-	-
-	05/23/90	1045	5,132.2	5,103.4	28.8	51	7.1	191	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/24/90	1125	-	-	-	52	7.1	189	-	-	-	<2.2	<2.2	<2.2	5.1	<2.2	<1	<1	-	-	-	-
-	05/29/90	0950	-	-	-	53	7.0	187	202	100	0.5	-	-	-	-	-	-	-	-	0.27	-	1.2
06Q3	09/26/89	1045	5,132.2	5,103.1	29.1	53	7.1	194	196	99	0.3	<2.2	<2.2	<2.2	-	-	-	-	100	0.30	0.2	1.2
-	09/27/89	1515	-	-	-	54	7.1	200	198	105	0.3	<2.2	<2.2	<2.2	-	-	-	-	134	0.20	0.26	0.9
-	05/21/90	1140	-	-	-	53	7.0	191	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/22/90	1015	-	-	-	52	7.1	191	-	-	-	<2.2	<2.2	<2.2	2.2	<2.2	<1	<1	-	-	-	-
-	05/23/90	-	5,132.2	5,103.3	28.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	05/24/90	1145	-	-	-	52	7.0	190	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	05/29/90	0915	-	-	-	53	7.0	190	202	101	0.5	-	-	-	-	-	-	-	-	0.25	-	1.2
06Q4	09/26/89	0945	5,132.6	5,103.7	28.9	53	7.1	192	194	104	1	<2.2	<2.2	<2.2	-	-	-	-	124	0.30	0.09	0.9
-	09/27/89	1415	-	-	-	54	6.9	198	196	92	0.5	<2.2	<2.2	<2.2	-	-	-	-	109	0.29	0.08	1.2
-	05/21/90	1110	-	-	-	53	7.0	192	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/22/90	0950	-	-	-	53	7.1	191	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/23/90	-	5,132.6	5,103.4	29.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	05/24/90	-	-	-	-	-	-	-	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/29/90	0855	-	-	-	53	7.0	191	202	103	0.6	-	-	-	-	-	-	-	-	0.29	-	0.9

Table 32. Field and laboratory results from Spalding Tract during the fall of 1989 and spring of 1990.

Well Number	Date	Time (PST)	Ground Elev. (ft)	Water Surface Elev. (ft)	Water Depth (ft)	Temp. (F)	pH	Electrical Conductivity (umhos/cm) Field	Electrical Conductivity (umhos/cm) Lab	Alkalinity (mg/L as CaCO3)	Turb. (NTU)	Bacteriological: Multiple Tube (MPN) TC	FC	FS	Colilert (MPN) TC	E. coli	Membrane Filter TC	FC	Chemical Analyses (mg/L) TDS	NO3-N	PO4-P	Cl
06Q5	09/26/89	1015	5,131.5	5,103.6	27.9	53	7.3	193	193	91	0.3	<2.2	<2.2	<2.2	-	-	-	-	101	0.32	0.13	1.2
-	09/27/89	1430	-	-	-	54	7.1	198	195	100	0.2	<2.2	<2.2	<2.2	-	-	-	-	101	0.29	0.12	0.9
-	05/21/90	1120	-	-	-	52	7.0	191	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/22/90	0955	-	-	-	52	7.1	191	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/23/90	1025	5,131.5	5,103.4	28.1	51	7.1	193	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/24/90	1225	-	-	-	52	7.1	190	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/29/90	0900	-	-	-	-	-	-	201	7.1	0.3	-	-	-	-	-	-	-	-	0.34	-	0.9
06R1	09/26/89	1430	5,122.9	5,103.8	19.1	52	7.1	274	284	124	0.2	<2.2	<2.2	<2.2	-	-	-	-	216	1.2	0.19	1.7
-	09/27/89	1445	-	-	-	52	7.1	283	277	135	0.3	<2.2	<2.2	<2.2	-	-	-	-	105	1.36	0.22	1.4
-	05/22/90	1240	-	-	-	52	7.1	305	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/29/90	-	5,122.9	5,103.4	19.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	05/29/90	1400	-	-	-	53	7.0	315	332	149	0.3	-	-	-	-	-	-	-	-	2.9	-	2.1
06R2	09/26/89	1240	5,132.2	5,103.6	28.6	55	7.1	193	199	99	0.5	<2.2	<2.2	<2.2	-	-	-	-	142	0.32	0.07	0.9
-	09/27/89	1620	-	-	-	56	7.1	202	198	102	0.5	<2.2	<2.2	<2.2	-	-	-	-	112	0.31	0.1	0.9
-	05/23/90	-	5,132.2	5,103.4	28.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
06R3	09/26/89	1310	5,126.0	5,103.7	22.3	53	7.1	200	205	104	0.2	<2.2	<2.2	<2.2	-	-	-	-	165	0.40	0.1	1.2
-	09/27/89	1645	-	-	-	52	7.1	210	208	95	0.2	<2.2	<2.2	<2.2	-	-	-	-	168	0.41	0.12	0.9
-	05/21/90	1330	-	-	-	52	7.1	202	-	-	-	<2.2	<2.2	2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/22/90	1100	-	-	-	53	7.1	200	-	-	-	<2.2	<2.2	2.2	9.2	<2.2	<1	<1	-	-	-	-
-	05/23/90	1100	-	-	-	51	7.1	203	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/29/90	-	5,126.0	5,103.5	22.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	05/29/90	1010	-	-	-	53	7.1	200	213	104	0.3	-	-	-	-	-	-	-	-	0.36	-	1.8
07A1	09/26/89	1500	5,125.2	5,103.6	21.6	54	7.1	242	249	128	0.5	<2.2	<2.2	<2.2	-	-	-	-	173	0.47	0.12	1.2
-	09/28/89	0910	-	-	-	55	7.3	253	249	114	0.6	<2.2	<2.2	<2.2	-	-	-	-	150	0.47	0.13	1.2
-	05/21/90	1410	-	-	-	52	7.1	234	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/22/90	1150	5,125.2	5,103.4	21.8	52	7.1	234	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/29/90	1100	-	-	-	52	7.1	250	267	132	2.0	-	-	-	-	-	-	-	-	0.52	-	1.2
07A2	09/26/89	1650	5,128.8	5,103.6	25.2	55	7.1	212	220	110	0.2	2.2	2.2	<2.2	-	-	-	-	175	0.21	0.09	1.2
-	09/28/89	1020	-	-	-	55	7.3	227	220	118	0.2	<2.2	<2.2	<2.2	-	-	-	-	173	0.19	0.1	1.2
-	05/21/90	1530	-	-	-	54	7.1	219	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/22/90	1330	5,128.8	5,103.4	25.4	54	7.1	218	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/29/90	1210	-	-	-	54	7.1	217	230	117	0.4	-	-	-	-	-	-	-	-	0.16	-	1.5
07A3	09/28/89	1025	5,131.6	5,103.8	27.8	55	7.1	210	-	-	-	<2.2	<2.2	<2.2	-	-	-	-	150	0.20	0.09	1.2
-	05/21/90	1425	-	-	-	53	7.1	211	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/22/90	1210	-	-	-	53	7.1	209	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/23/90	-	5,131.6	5,103.5	28.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	05/29/90	1115	-	-	-	53	7.1	209	223	111	0.3	-	-	-	-	-	-	-	-	0.16	-	1.2

Table 32. Field and laboratory results from Spalding Tract during the fall of 1989 and spring of 1990.

Well Number	Date	Time (PST)	Ground Elev. (ft)	Water Surface Elev. (ft)	Water Depth (ft)	Temp. (F)	pH	Electrical Conductivity (umhos/cm) Field	Electrical Conductivity (umhos/cm) Lab	Alkalinity (mg/L as CaCO3)	Turb. (NTU)	Bacteriological: Multiple Tube (MPN) TC	Multiple Tube (MPN) FC	Multiple Tube (MPN) FS	Colilert (MPN) TC	Colilert (MPN) E. coli	Membrane Filter TC	Membrane Filter FC	Chemical Analyses (mg/L) TDS	NO3-N	PO4-P	Cl
07A4	09/28/89	1200	5,129.7	5,103.6	26.1	53	7.1	206	210	116	0.2	<2.2	<2.2	<2.2	-	-	-	-	152	0.35	0.1	1.2
-	05/21/90	1430	-	-	-	52	7.1	206	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/22/90	1215	5,129.7	5,103.4	26.3	52	7.1	206	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/29/90	1120	-	-	-	53	7.1	206	219	109	0.4	-	-	-	-	-	-	-	-	0.32	-	1.5
07B1	09/26/89	1330	-	-	-	56	7.1	200	202	105	0.3	<2.2	<2.2	<2.2	-	-	-	-	195	0.28	0.12	1.4
-	09/28/89	0815	-	-	-	56	7.1	212	203	110	0.4	<2.2	<2.2	<2.2	-	-	-	-	132	0.26	0.08	1.2
-	05/21/90	1345	-	-	-	54	7.1	200	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/22/90	1130	-	-	-	54	7.1	199	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/23/90	1120	-	-	-	53	7.1	201	-	-	-	16	<2.2	2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/24/90	1105	-	-	-	53	7.1	199	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/29/90	1035	-	-	-	54	7.1	199	210	106	0.9	-	-	-	-	-	-	-	-	0.20	-	1.2
07B3	09/26/89	1540	5,143.3	5,103.7	39.6	56	7.1	196	201	85	0.4	<2.2	<2.2	<2.2	-	-	-	-	98	0.34	0.08	1.2
-	09/28/89	0940	-	-	-	55	7.3	203	199	94	0.3	<2.2	<2.2	<2.2	-	-	-	-	97	0.32	0.11	1.2
-	05/21/90	1500	-	-	-	54	7.1	194	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/22/90	1305	5,143.3	5,103.5	39.8	54	7.1	193	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/29/90	1140	-	-	-	55	7.1	194	206	104	0.3	-	-	-	-	-	-	-	-	0.36	-	1.2
07B4	09/26/89	1630	5,134.4	5,103.6	30.8	56	7.1	194	199	100	0.2	<2.2	<2.2	<2.2	-	-	-	-	100	0.40	0.07	1.7
-	09/28/89	1005	-	-	-	56	7.1	205	201	95	0.3	<2.2	<2.2	<2.2	-	-	-	-	152	0.34	0.09	1.2
-	05/21/90	1515	-	-	-	53	7.1	199	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/22/90	1320	5,134.4	5,103.4	31.0	54	7.1	197	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/24/90	1050	-	-	-	51	7.2	198	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/29/90	1205	-	-	-	55	7.1	196	208	105	0.5	-	-	-	-	-	-	-	-	0.41	-	1.2
07B5	09/26/89	1400	-	-	-	56	7.1	197	199	104	0.3	<2.2	<2.2	<2.2	-	-	-	-	143	0.30	0.08	1.2
-	09/28/89	0840	-	-	-	57	7.1	203	201	103	0.2	<2.2	<2.2	<2.2	-	-	-	-	164	0.29	0.11	1.2
-	05/21/90	1355	-	-	-	55	7.1	199	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/22/90	1125	-	-	-	56	7.1	196	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/29/90	1030	-	-	-	55	7.0	197	208	105	0.3	-	-	-	-	-	-	-	-	0.23	-	1.2
07B2	09/27/89	0815	5,152.4	5,103.9	48.5	55	7.1	199	197	89	0.3	<2.2	<2.2	<2.2	-	-	-	-	131	0.30	0.08	0.9
-	09/28/89	1050	-	-	-	55	7.1	203	199	107	0.2	2.2	<2.2	<2.2	-	-	-	-	57	0.30	0.1	1.2
-	05/22/90	0720	5,152.4	5,103.7	48.7	55	7.1	198	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/22/90	1350	-	-	-	55	7.1	196	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/24/90	1030	-	-	-	54	7.1	196	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/29/90	1235	-	-	-	55	7.0	196	207	113	0.4	-	-	-	-	-	-	-	-	0.36	-	1.2

Table 32. Field and laboratory results from Spalding Tract during the fall of 1989 and spring of 1990.

Well Number	Date	Time (PST)	Ground Elev. (ft)	Water Surface Elev. (ft)	Water Depth (ft)	Temp. (F)	pH	Electrical Conductivity (umhos/cm) Field	Electrical Conductivity (umhos/cm) Lab	Alkalinity (mg/L as CaCO3)	Turb. (NTU)	Bacteriological: Multiple Tube (MPN) TC	Multiple Tube (MPN) FC	Multiple Tube (MPN) FS	Colilert (MPN) TC	Colilert (MPN) E. coli	Membrane Filter TC	Membrane Filter FC	Chemical Analyses (mg/L) TDS	NO3-N	PO4-P	Cl
07C1	09/26/89	1535	5,145.2	5,103.8	41.4	54	7.3	196	193	108	0.7	<2.2	<2.2	<2.2	-	-	-	-	166	0.28	0.09	1.4
-	09/28/89	0915	-	-	-	54	7.1	192	194	88	0.3	<2.2	<2.2	<2.2	-	-	-	-	124	0.25	0.11	0.9
-	05/22/90	0830	-	-	-	52	7.3	204	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	1	<1	-	-	-	-
-	05/22/90	1545	-	-	-	53	7.3	190	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	05/24/90	1530	-	-	-	52	7.1	188	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/29/90	1455	-	-	-	53	7.3	202	199	108	0.5	-	-	-	-	-	-	-	-	0.27	-	1.5
07C2	09/26/89	1435	5,137.4	5,103.7	33.7	57	7.3	192	190	104	0.2	2.2	<2.2	<2.2	-	-	-	-	190	0.30	0.09	1.2
-	09/27/89	1630	-	-	-	57	7.1	187	194	100	0.3	5.1	<2.2	<2.2	-	-	-	-	101	0.31	0.09	1.2
-	05/24/90	-	5,137.4	5,103.5	33.9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
07C3	09/26/89	1555	-	-	-	57	7.3	200	194	98	0.3	<2.2	<2.2	<2.2	-	-	-	-	108	0.32	0.08	1.2
-	09/28/89	0850	5,142.3	5,102.8	39.5	56	7.1	198	193	98	0.3	<2.2	<2.2	<2.2	-	-	-	-	92	0.30	0.09	1.2
-	05/22/90	0900	-	-	-	55	7.3	190	-	-	-	>16	5.1	<2.2	>16	5.1	20	1	-	-	-	-
-	05/22/90	1605	-	-	-	55	7.3	190	-	-	-	>16	5.1	<2.2	NT	NT	32	2	-	-	-	-
-	05/23/90	1320	-	-	-	54	7.3	205	-	-	-	80	7	<2.2	30	8	25	3	-	-	-	-
-	05/24/90	1630	5,142.3	5,103.3	39.0	56	7.1	189	-	-	-	80	<2	<2	22	2	13	2	-	-	-	-
-	05/29/90	1340	-	-	-	55	7.3	203	197	100	0.3	-	-	-	-	-	-	-	-	0.29	-	1.2
07C4	09/26/89	1510	5,136.3	5,103.7	32.6	55	7.3	194	198	96	0.5	<2.2	<2.2	<2.2	-	-	-	-	170	0.94	0.11	1.2
-	09/27/89	1700	-	-	-	56	7.1	192	199	101	0.4	<2.2	<2.2	<2.2	-	-	-	-	112	0.94	0.1	1.4
-	05/22/90	0810	-	-	-	54	7.1	192	-	-	-	2.2	<2.2	<2.2	<2.2	<2.2	1	<1	-	-	-	-
-	05/22/90	1600	-	-	-	53	7.1	194	-	-	-	5.1	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/24/90	1515	5,136.3	5,103.1	33.2	54	7.1	180	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/29/90	1320	-	-	-	54	7.3	195	-	-	-	-	-	-	-	-	-	-	-	1.45	-	1.2
07C5	09/26/89	1410	5,138.3	5,103.8	34.5	57	7.3	196	193	97	0.3	<2.2	<2.2	<2.2	-	-	-	-	178	0.40	0.14	1.2
-	09/27/89	1615	-	-	-	58	7.2	189	195	98	0.3	<2.2	<2.2	2.2	-	-	-	-	130	0.31	0.1	1.2
-	05/22/90	0755	-	-	-	56	7.1	201	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/22/90	1545	-	-	-	55	7.1	202	-	-	-	<2.2	<2.2	<2.2	NT	NT	<1	<1	-	-	-	-
-	05/24/90	-	5,138.3	5,103.5	34.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	05/29/90	1300	-	-	-	55	7.3	202	195	98	0.3	-	-	-	-	-	-	-	-	0.29	-	1.2
07C6	09/26/89	1625	5,150.1	5,103.7	46.4	55	7.3	201	194	112	0.2	<2.2	<2.2	<2.2	-	-	-	-	131	0.26	0.08	1.2
-	09/28/89	0940	-	-	-	56	7.2	190	195	100	0.2	<2.2	<2.2	<2.2	-	-	-	-	145	0.24	0.09	1.2
-	05/22/90	0930	-	-	-	56	7.1	204	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/22/90	1620	5,150.1	5,103.5	46.5	54	7.1	192	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/24/90	1605	-	-	-	54	7.1	190	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	1	2	-	-	-	-
-	05/29/90	1415	-	-	-	54	7.3	204	198	94	0.2	-	-	-	-	-	-	-	-	0.32	-	1.2

Table 32. Field and laboratory results from Spalding Tract during the fall of 1989 and spring of 1990.

Well Number	Date	Time (PST)	Ground Elev. (ft)	Water Surface Elev. (ft)	Water Depth (ft)	Temp. (F)	pH	Electrical Conductivity (umhos/cm) Field	Lab	Alkalinity (mg/L as CaCO3)	Turb. (NTU)	Bacteriological: Multiple Tube (MPN) TC	FC	FS	Colilert (MPN) TC	E. coli	Membrane Filter TC	FC	Chemical Analyses (mg/L) TDS	NO3-N	PO4-P	Cl
07D1	09/26/89	1335	5,147.6	5,103.3	44.3	58	7.3	197	192	99	0.3	<2.2	<2.2	<2.2	-	-	-	-	126	0.23	0.12	0.9
-	09/27/89	1600	-	-	-	59	7.2	189	194	91	0.2	<2.2	<2.2	<2.2	-	-	-	-	144	0.21	0.1	1.2
-	05/22/90	0735	-	-	-	56	7.1	201	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/22/90	1530	-	-	-	56	7.1	201	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/24/90	-	5,147.6	5,102.5	45.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	05/29/90	1250	-	-	-	55	7.4	200	195	93	0.2	-	-	-	-	-	-	-	-	0.32	-	1.2
07G1	09/27/89	0930	5,137.5	-	-	54	6.9	195	199	103	2.1	<2.2	<2.2	<2.2	-	-	-	-	31	0.16	0.08	1.2
-	09/28/89	1145	-	-	-	54	7.1	204	205	111	1.7	<2.2	<2.2	<2.2	-	-	-	-	173	0.17	0.12	1.2
07G2	09/27/89	0845	5,148.0	5,103.6	44.4	56	7.1	204	197	97	0.5	<2.2	<2.2	<2.2	-	-	-	-	154	0.24	0.09	1.2
-	09/28/89	1105	-	-	-	56	7.1	203	208	103	0.5	5.1	<2.2	<2.2	-	-	-	-	107	0.25	0.19	1.2
-	10/10/89	1200	-	-	-	56	7.1	205	-	-	-	<2	<2	<2	-	-	-	-	-	-	-	-
-	10/10/89	1200	-	-	-	56	7.1	205	-	-	-	2	2	<2	-	-	-	-	-	-	-	-
-	05/22/90	0730	5,148.0	5,103.4	44.6	55	7.1	198	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/22/90	1355	-	-	-	55	7.1	196	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/24/90	1030	-	-	-	54	7.2	195	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/29/90	1240	-	-	-	55	7.1	194	209	103	0.3	-	-	-	-	-	-	-	-	0.27	-	0.9
07G3	09/27/89	0910	5,139.7	5,103.6	36.1	54	7.1	208	207	99	0.4	>16	>16	<2.2	-	-	-	-	66	0.54	0.11	1.7
-	09/28/89	1125	-	-	-	54	6.9	210	220	126	0.2	>16	>16	<2.2	-	-	-	-	183	0.48	0.11	1.2
-	10/10/89	1240	-	-	-	54	6.9	215	-	-	-	5000	300	<2	-	-	-	-	-	-	-	-
-	10/10/89	1240	-	-	-	54	6.9	215	-	-	-	17000	230	<2	-	-	-	-	-	-	-	-
-	12/04/89	-	-	-	-	-	-	-	-	-	-	3000	4	<2	-	-	-	-	-	-	-	-
-	12/04/89	-	-	-	-	-	-	-	-	-	-	2300	22	<2	-	-	-	-	-	-	-	-
-	05/21/90	1555	-	-	-	53	7	203	-	-	-	>16	>16	<2.2	2400	130	TNTC	140	-	-	-	-
-	05/22/90	1425	-	-	-	53	6.9	202	-	-	-	16000	130	<2	1300	110	1100	50	-	-	-	-
-	05/23/90	1140	5,139.7	5,103.5	36.2	51	6.9	206	-	-	-	500	30	<2.2	80	80	3300	64	-	-	-	-
-	05/29/90	1305	-	-	-	53	6.9	204	215	105	0.3	-	-	-	-	-	-	-	-	0.59	-	1.5
07H1	09/27/89	0950	5,129.5	5,103.6	25.9	54	6.9	204	208	102	0.2	<2.2	<2.2	<2.2	-	-	-	-	173	0.35	0.08	1.2
-	09/28/89	1205	-	-	-	54	6.7	210	211	109	0.3	2.2	<2.2	<2.2	-	-	-	-	128	0.31	0.09	1.2
-	05/22/90	-	5,129.5	5,103.4	26.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
07J1	09/27/89	1030	5,122.6	5,103.6	19.0	53	7.1	194	200	105	0.3	<2.2	<2.2	<2.2	-	-	-	-	110	0.21	0.08	1.2
-	09/28/89	1230	-	-	-	53	7.1	196	202	105	0.3	<2.2	<2.2	<2.2	-	-	-	-	133	0.20	0.1	1.2
-	05/22/90	0810	5,122.6	5,103.1	19.5	52	7.1	192	-	-	-	<2.2	<2.2	<2.2	<2.2	2.2	<1	<1	-	-	-	-
-	05/22/90	1445	-	-	-	52	7.0	192	-	-	-	<2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/29/90	1325	-	-	-	52	7.0	191	201	102	0.4	-	-	-	-	-	-	-	-	0.23	-	1.2

Table 32. Field and laboratory results from Spalding Tract during the fall of 1989 and spring of 1990.

Well Number	Date	Time (PST)	Ground Elev. (ft)	Water Surface Elev. (ft)	Water Depth (ft)	Temp. (F)	pH	Electrical Conductivity (umhos/cm) Field	Electrical Conductivity (umhos/cm) Lab	Alkalinity (mg/L as CaCO3)	Turb. (NTU)	Bacteriological: Multiple Tube (MPN) TC	Multiple Tube (MPN) FC	Multiple Tube (MPN) FS	Colilert (MPN) TC	Colilert (MPN) E. coli	Membrane Filter TC	Membrane Filter FC	Chemical Analyses (mg/L) TDS	NO3-N	PO4-P	Cl
07R1	09/27/89	1100	5,116.0	5,103.6	12.4	-	7.1	194	195	102	0.3	<2.2	<2.2	<2.2	-	-	-	-	122	0.21	0.08	1.2
-	09/28/89	1230	-	-	-	58	7.1	201	197	105	0.3	<2.2	<2.2	<2.2	-	-	-	-	112	0.21	0.1	1.2
-	05/22/90	0825	5,116.0	5,103.4	12.6	53	7.1	189	-	-	-	2.2	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/22/90	1500	-	-	-	54	7.1	188	-	-	-	16	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/24/90	1000	-	-	-	53	7.1	186	-	-	-	5.1	<2.2	<2.2	<2.2	<2.2	<1	<1	-	-	-	-
-	05/29/90	1340	-	-	-	53	7.1	187	198	100	0.4	-	-	-	-	-	-	-	-	0.25	-	0.9
Eagle Lake	09/27/89	1120	-	5,103.6	-	64	9.1	889	899	518	2.3	11	4	8	-	-	-	-	562	0.03	0.05	12.0
(south)	09/28/89	1120	-	-	-	64	9.1	896	921	508	1	4	2	9	-	-	-	-	604	0.01	0.07	12.0
-	05/29/90	1430	-	5,103.4	-	61	9.1	910	878	509	1.8	-	-	-	-	-	-	-	-	0.07	-	12.0
Eagle Lake	09/27/89	1150	-	5,103.6	-	64	9.2	908	918	458	2.4	17	17	<2.2	-	-	-	-	519	0.01	0.05	13.0
(north)	09/28/89	1050	-	-	-	64	9.1	912	946	435	1.4	12	4	4	-	-	-	-	568	0.01	0.04	13.0
-	05/29/90	1450	-	5,103.4	-	56	9.1	976	942	509	1.3	-	-	-	-	-	-	-	-	<0.05	-	13.0

Total dissolved solids measurements were selected to provide information about mineralization of the ground water at Spalding Tract. Electrical conductivity, which is related to total dissolved solids, can be used to evaluate variations in dissolved mineral concentrations in water. Electrical conductivity results from Spalding Tract allow determination of any increasing mineral inputs from "upgradient" to "downgradient" wells. A slight increase in electrical conductivity from upgradient to downgradient wells is apparent from both the fall 1989 (Figure 20) and spring 1990 (Figure 21) monitoring results. Electrical conductivity measurements increased from about 175-180 µmhos/cm at upgradient wells to about 200 µmhos/cm at downgradient wells during both study periods. Apparently, ground water at the northwestern extreme of the subdivision is less mineralized than water moving into the subdivision from the west, which may reflect some influence from the less mineralized water in Pine Creek. Electrical conductivity values were substantially lower at the northern wells. Relatively high electrical conductivity levels were found in wells close to Eagle Lake. These higher than typical values may be due to inland migration of lake water, which had electrical conductivity levels of over 900 µmhos/cm, due to ground water extraction and lack of gradient between the ground water and lake. Some of the higher electrical conductivity levels in wells near the lake, as well as a few inland wells (07A3 and 07G3), may be due to other sources, such as mineral deposits or septic system effluent.

Nitrate nitrogen concentrations ranged from 0.16 to 1.40 mg/L during the fall measurements. Concentrations in wells in the north-western, or upgradient, portion of Spalding Tract contained about 0.22 to 0.23 mg/L of nitrate nitrogen (Figure 22). Wells considered downgradient generally increased slightly in nitrate nitrogen concentration in the direction that ground water would be expected to flow, although some wells were as low or lower in concentration than the upgradient wells. The wells closest to Eagle Lake generally contained nitrate nitrogen concentrations of about 0.20 to 0.30 mg/L. Throughout the subdivision, a few wells were found to contain greater concentrations of nitrate nitrogen than surrounding upgradient and downgradient wells. Well 06N1 had the greatest nitrate nitrogen concentration reported during the fall (1.40 mg/L) from the sample collected on September 26, but was reported to contain only 0.31 mg/L from the September 27 sample, which may indicate a laboratory error. Replicate results from

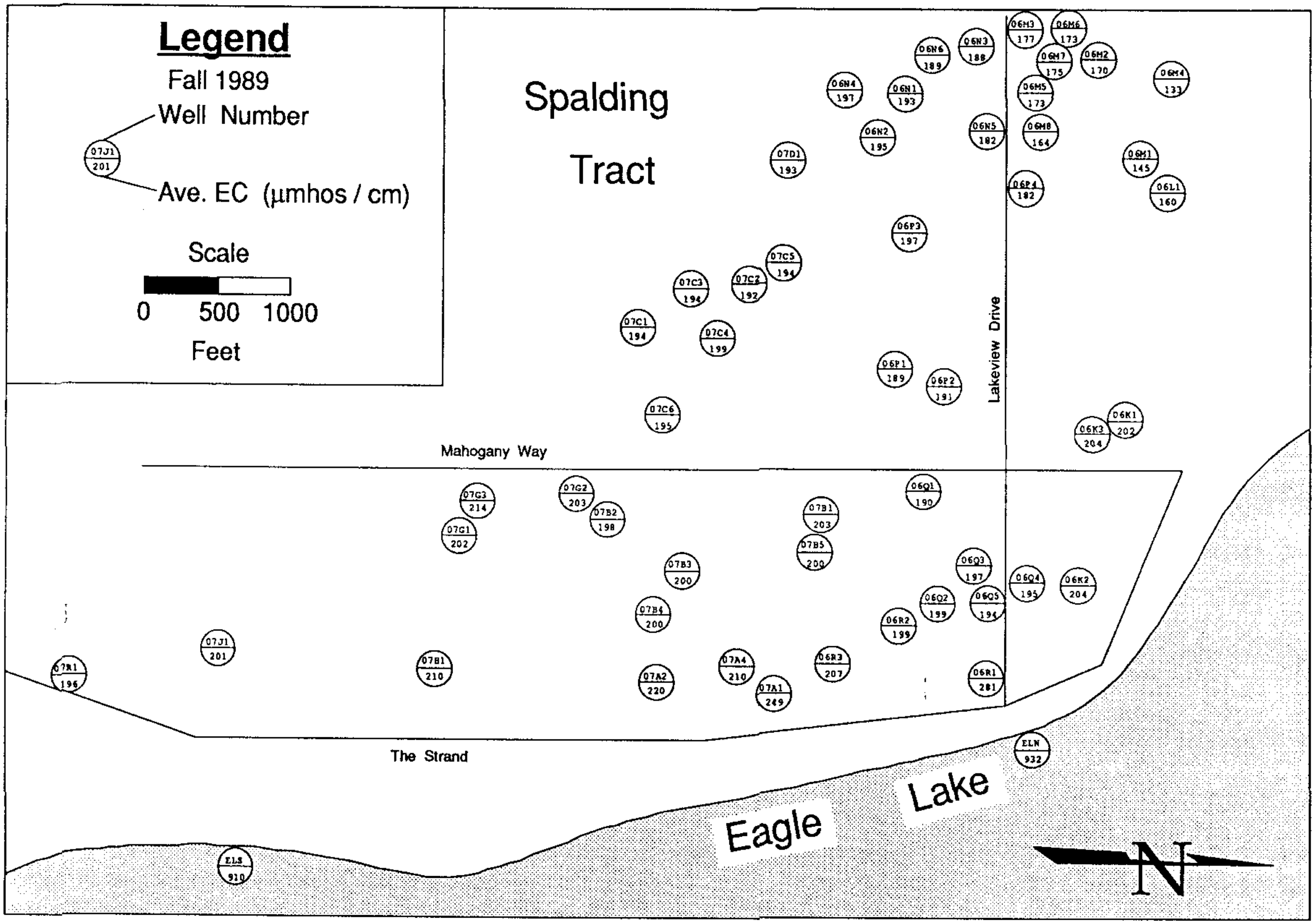


Figure 20. Average electrical conductivity levels from wells at Spalding Tract during fall 1989.

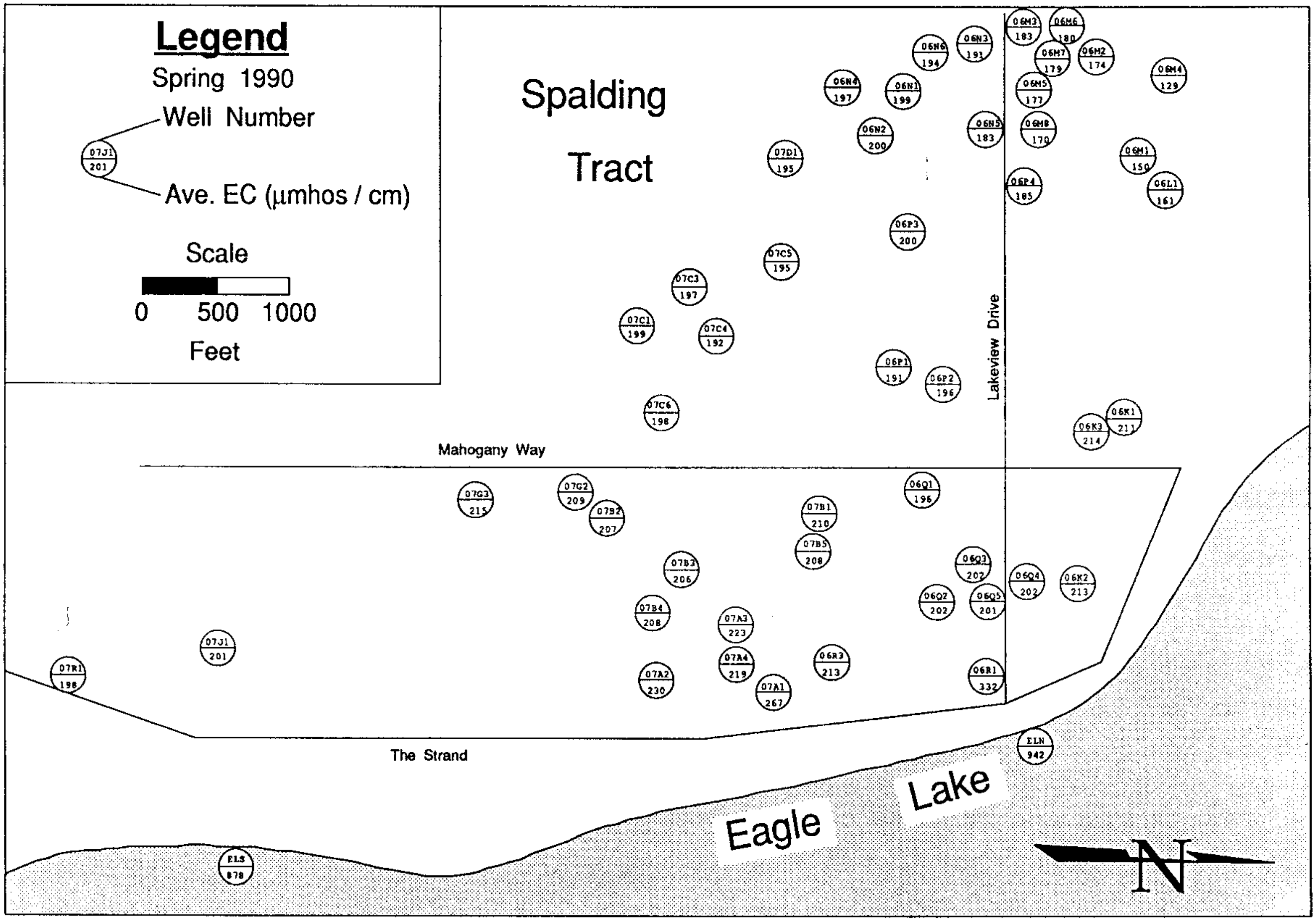


Figure 21. Average electrical conductivity levels from wells at Spalding Tract during spring 1990.

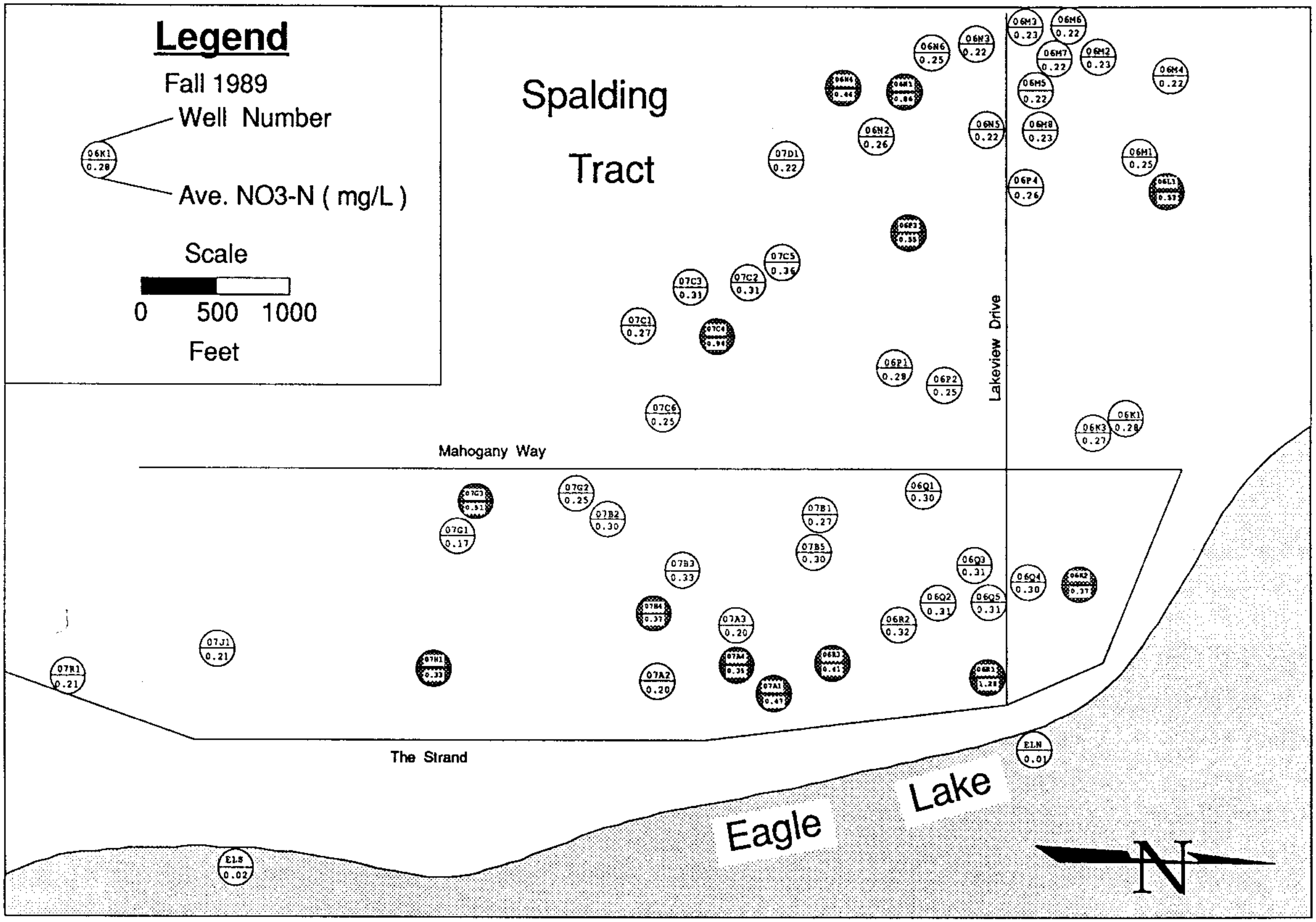


Figure 22. Average nitrate nitrogen concentrations from wells at Spalding Tract during fall 1989 (shaded wells contained concentrations dissimilar to surrounding wells).

the other wells were very similar to each other. The greatest average nitrate nitrogen concentration reported (1.28 mg/L) was from well 06R1 (Frey) located near the lake.

The spring 1990 nitrate nitrogen concentrations were generally slightly greater than the fall measurements, ranging from 0.16 to 2.9 mg/L (Figure 23). Wells in the north-western part of Spalding Tract were reported to contain nitrate nitrogen concentrations of about 0.25 to 0.27 mg/L. Nitrate nitrogen concentrations from wells throughout the subdivision were very similar to those in the upgradient wells, but many wells were reported to contain concentrations that were slightly to substantially greater than surrounding wells. Most of the wells exhibiting elevated nitrate nitrogen concentrations were the same wells found with elevated concentrations the previous fall. Well 06R1 again contained the greatest reported nitrate nitrogen concentration (2.9 mg/L).

Ortho-phosphate phosphorus concentrations ranged from 0.05 to 0.26 mg/L during the fall period. Upgradient wells contained about 0.06 to 0.08 mg/L of ortho-phosphate phosphorus, while downgradient wells generally contained slightly greater concentrations, ranging to about 0.10 mg/L (Figure 24). A few scattered wells contained greater concentrations, with the greatest concentrations found in wells 06Q3 (0.26 mg/L) and 06R1 (0.22 mg/L).

Ortho-phosphate phosphorus results from samples collected during the spring of 1990 were not available due to laboratory analytical error.

Chloride concentrations ranged from 0.9 to 1.7 mg/L during the fall monitoring. Upgradient wells generally contained average chloride concentrations of 1.2 mg/L (Figure 25). One of the two wells (06N2) with the least reported chloride concentration (0.9 mg/L) is downgradient from two other wells (06N1 and 06N4) with much greater chloride concentrations (1.5 mg/L). The other well with the least reported chloride concentration (06R2) is downgradient from most wells in the subdivision. Chloride concentrations were generally uniform throughout the subdivision, with an occasional well with slightly greater concentrations. Well 06R1 contained the greatest chloride concentration reported from Spalding Tract.

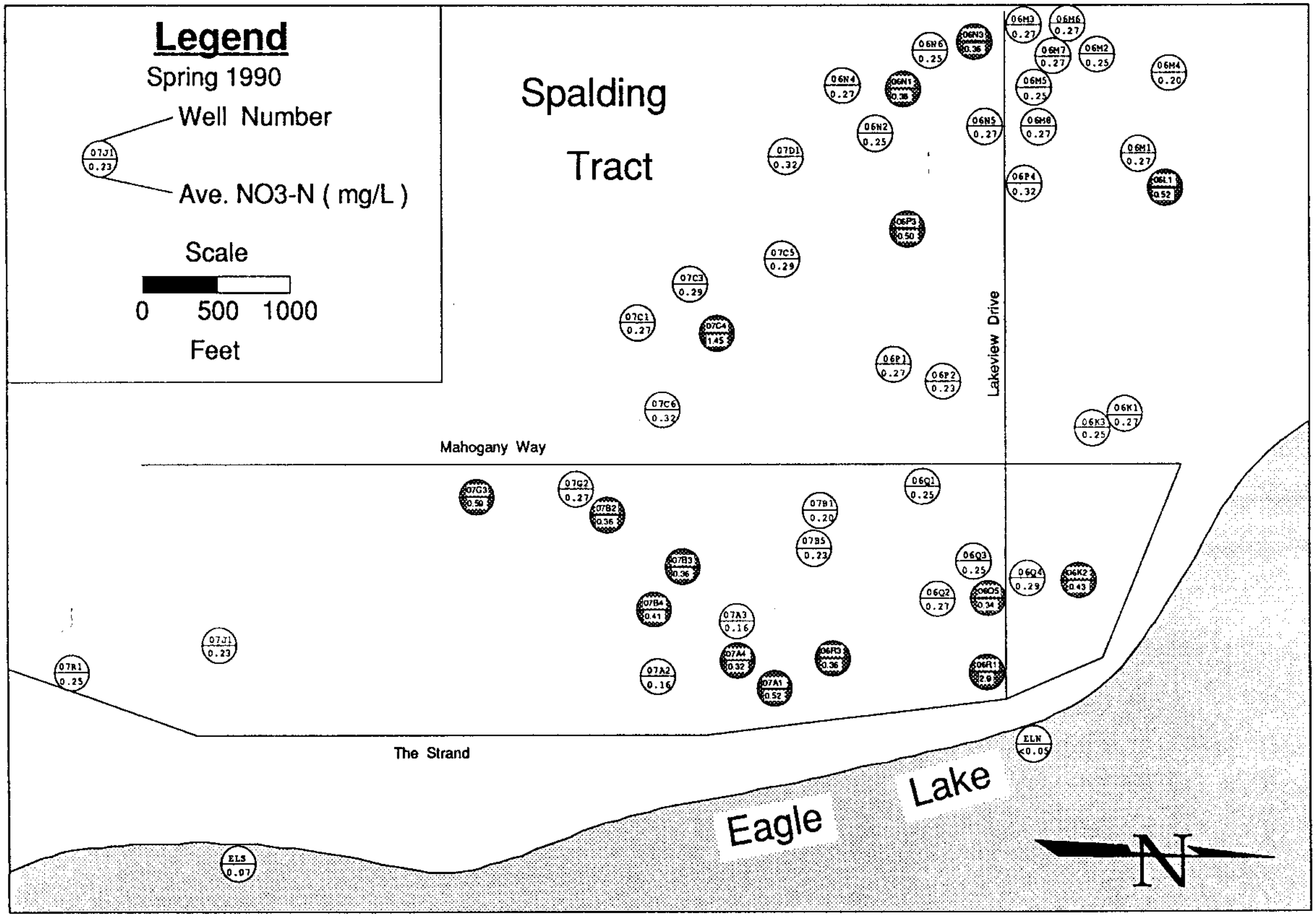


Figure 23. Average nitrate nitrogen concentrations from wells at Spalding Tract during spring 1990 (shaded wells contained concentrations dissimilar to surrounding wells).

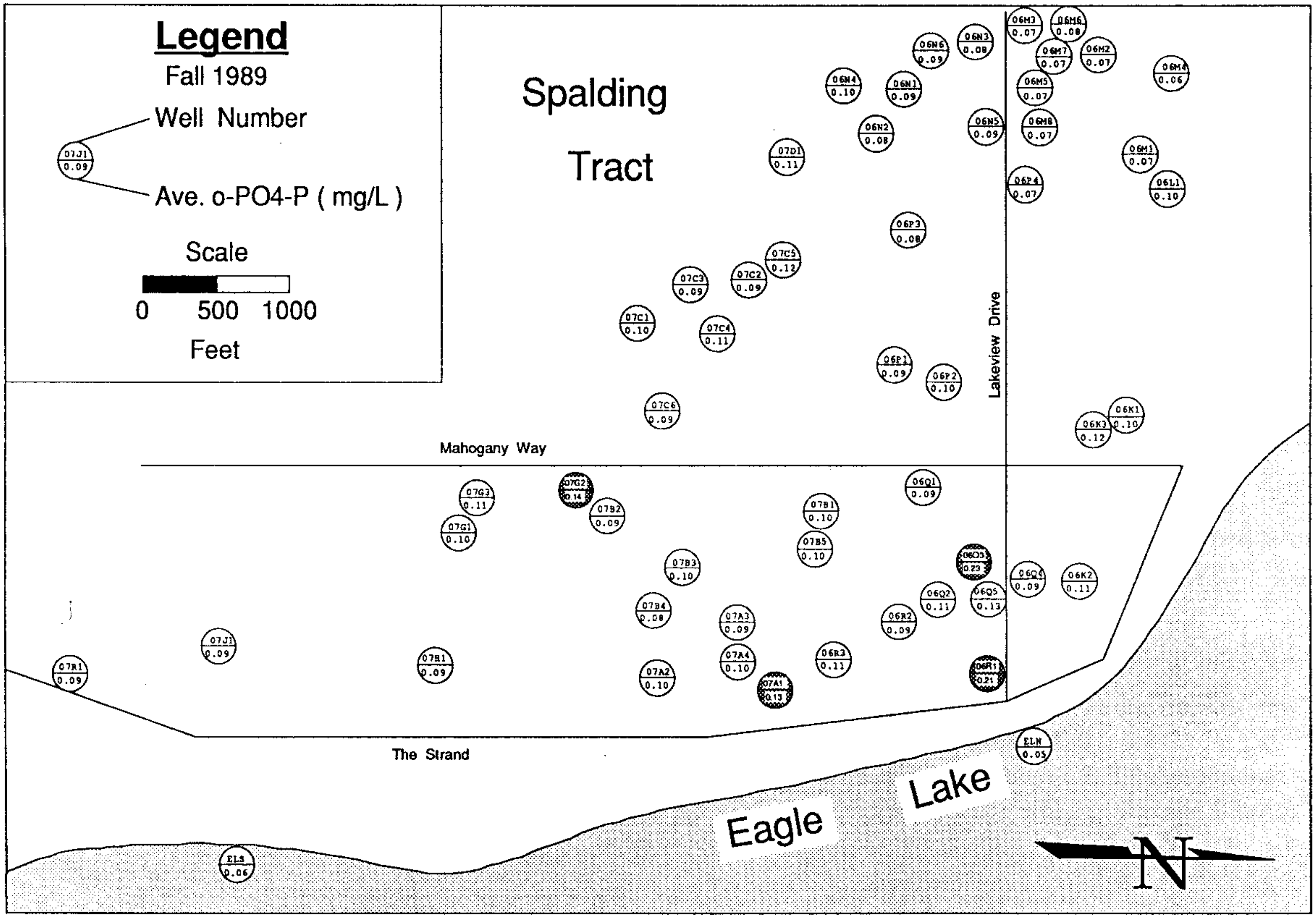


Figure 24. Average ortho-phosphate phosphorus from wells at Spalding Tract during fall 1989 (shaded wells contained concentrations dissimilar to surrounding wells).

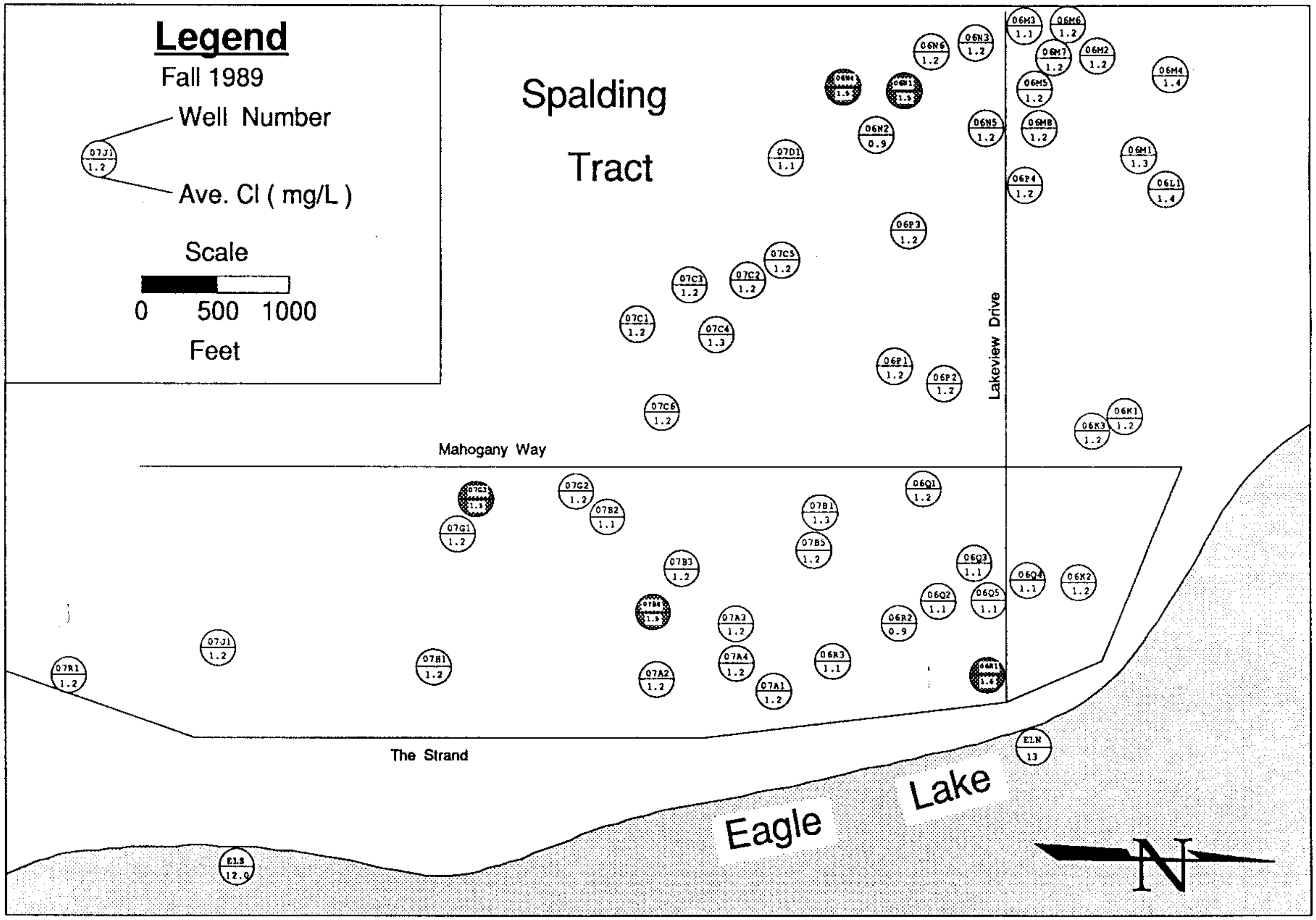


Figure 25. Average chloride concentrations from wells at Spalding Tract during fall 1989 (shaded wells contained concentrations dissimilar to surrounding wells).

Chloride concentrations reported during the spring of 1990 were generally about 1.2 mg/L throughout the subdivision, but ranged from 0.9 to 2.1 mg/L (Figure 26). Several of the wells exhibiting elevated chloride concentrations during the previous fall continued to exhibit elevated concentrations during the spring, with several additional wells also exhibiting elevated concentrations. The greatest chloride concentration (2.1 mg/L) was reported from well 06R1, while an upgradient well (06N3) contained a chloride concentration nearly as high (1.8 mg/L).

Eagle Lake had average electrical conductivity levels of 910 µmhos/cm off the south shore to 932 µmhos/cm off the north shore of Spalding Tract during the fall 1989. Measurements in the spring 1990 produced conductivity levels ranging from 878 µmhos/cm from the south shore to 942 µmhos/cm along the north shore. Average nitrate nitrogen concentrations ranged from 0.02 mg/L along the south shore to 0.01 mg/L along the north shore during the fall, and 0.07 mg/L along the south shore to less than 0.05 mg/L along the north shore during the spring. Ortho-phosphate phosphorus concentrations were greater along the south shore (0.05 to 0.07 mg/L) than the north shore (0.04 to 0.05 mg/L) during the fall. Chloride concentrations ranged from 12 mg/L along the south shore to 13 mg/L along the north shore during both the fall and spring.

Sixteen of the 52 wells exhibited a positive response during the fall bacteriological testing (Figure 27). Total coliform bacteria were found in samples from 14 wells, of which 5 were also positive for fecal coliform bacteria and 3 were also positive for fecal streptococcus. The two other wells were positive only for fecal streptococcus. Bacterial levels in most of the wells with positive responses were low. Eight of the wells had only 2.2 most probable number (MPN) of bacteria, while 5 wells had 5.1 MPN. The other three wells (06N4, 06N6, and 07G3) contained bacteria exceeding the maximum reportable number of bacteria for the analysis technique. Additional samples collected in October 1989 from well 06N6 produced total coliform counts as high as 130 colonies per 100 milliliters (mL) of sample, fecal coliform of 13 colonies per 100 mL, and fecal streptococcus of 80 colonies per 100 mL (Table 32). Subsequent samples in December 1989 yielded total coliform counts of only 2 colonies per 100 mL. Samples collected in October from well 07G3 yielded total coliform bacteria counts as high as 17,000 colonies per 100 mL, with fecal coliform colonies of up to

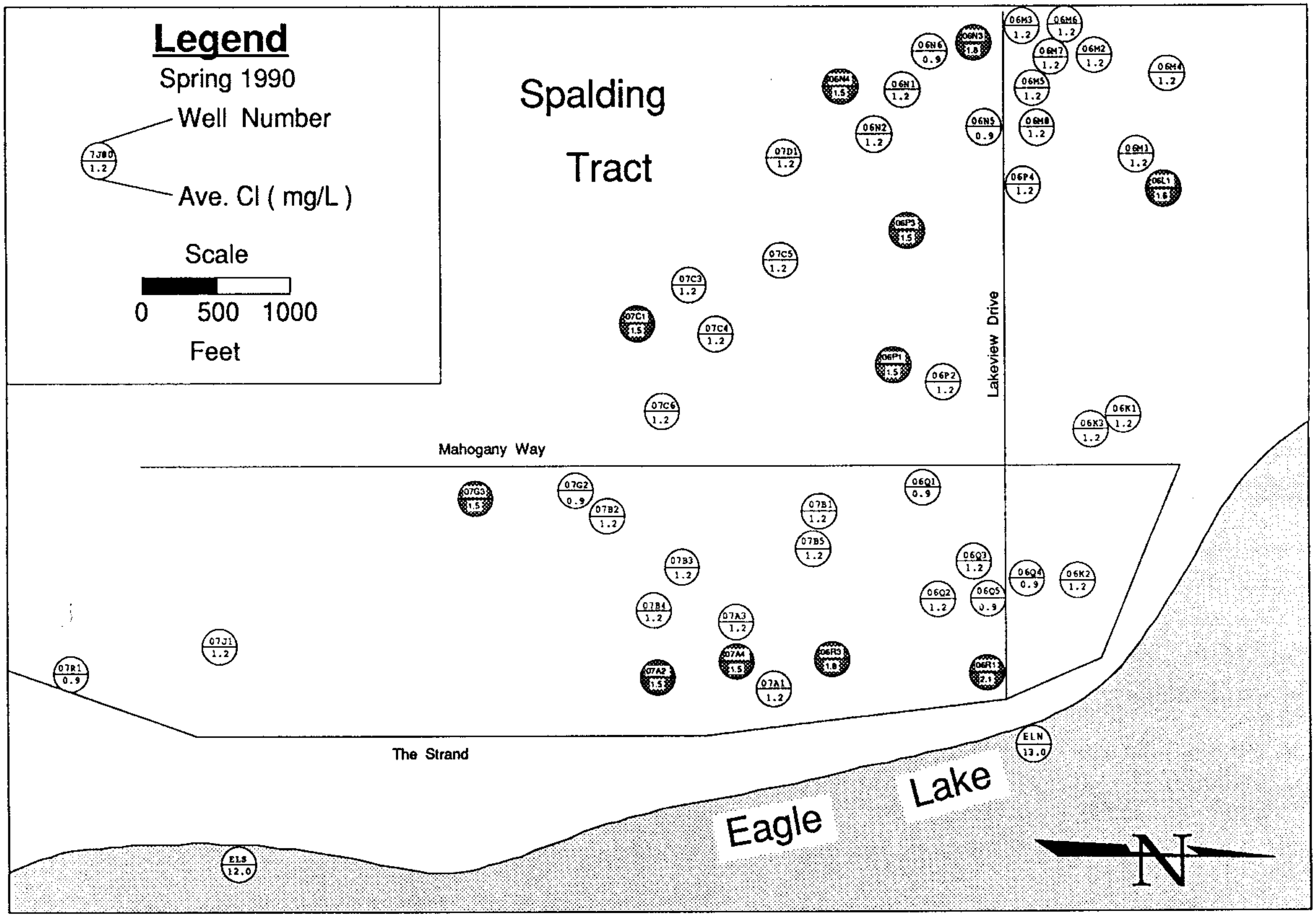


Figure 26. Average chloride concentrations from wells at Spalding Tract during spring 1990 (shaded wells contained concentrations dissimilar to surrounding wells).

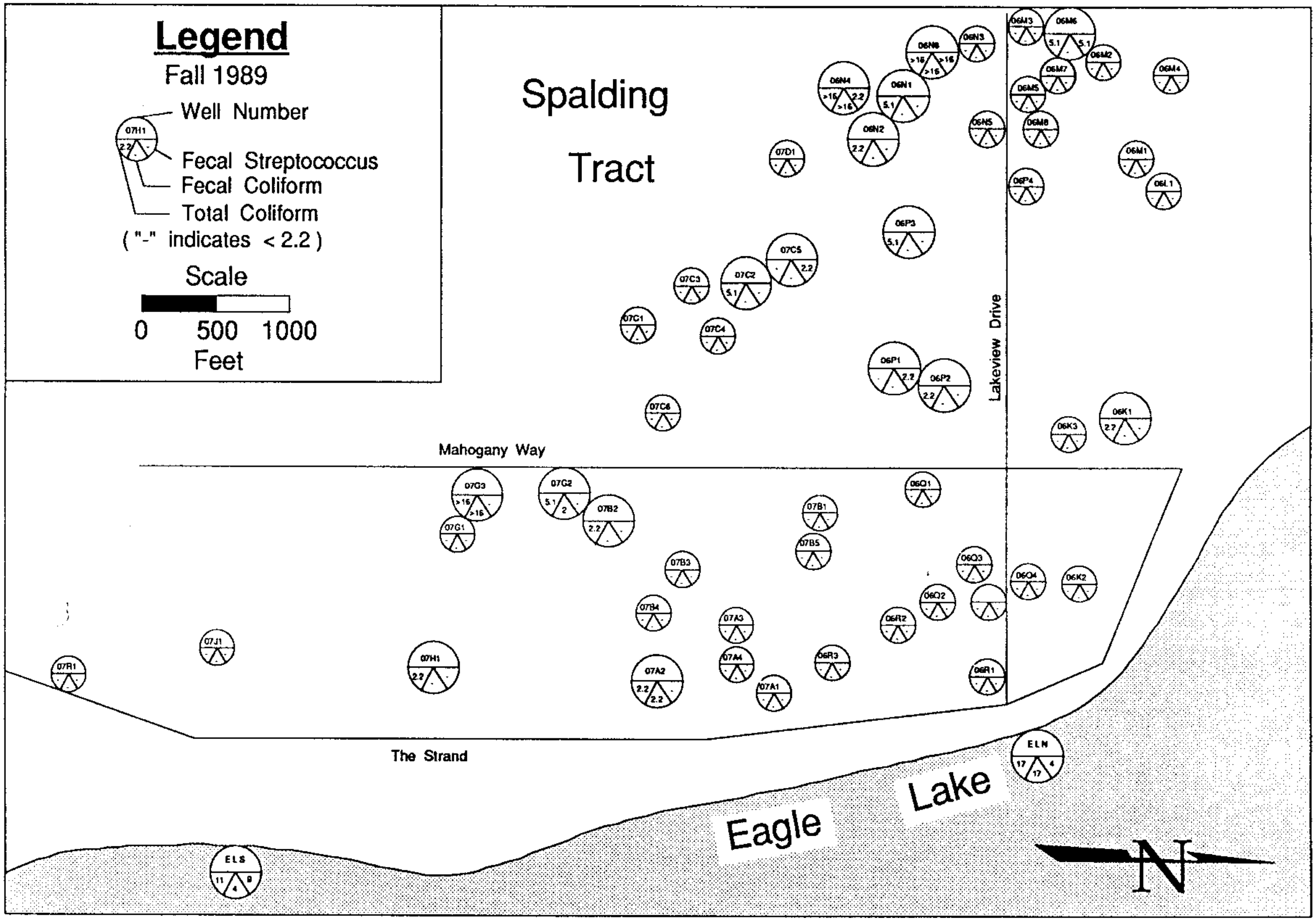


Figure 27. Bacteriological monitoring results from wells at Spalding Tract during fall 1989.

300 per 100 mL, but no fecal streptococcus. Subsequent analyses in December produced total coliform colonies up to 3,000 per 100 mL, and fecal coliform colonies of up to 22 per 100 mL.

Ten wells sampled during the spring of 1990 exhibited bacterial contamination from the multiple tube analysis (Figure 28). Total coliform bacteria were detected from eight of the wells, of which fecal coliform bacteria were also found in 3 of the wells and fecal streptococcus bacteria were found in 2 of the wells. The other two wells contained only fecal streptococcus. Three wells contained bacteria at the minimum detection limit, while bacterial numbers exceeded the maximum reportable for the analysis technique from three other wells (06M7, 07C3, and 07G3). Seven of the wells exhibiting bacterial contamination had not been reported to contain bacteria during the previous fall.

Total coliform and *Escherichia coli* (*E. coli*) bacteria were detected using the Colilert methodology during the spring from three additional wells in which bacteria had not previously been detected (Table 32). The membrane filter technique yielded very low counts (1 bacterium/100 mL) of total coliform bacteria from two additional wells, of which one also yielded a low count (2 bacteria/100 mL) of fecal coliform bacteria.

A total of 28 of the 52 wells that were monitored during the study exhibited bacterial contamination. Most of the wells exhibited sporadic contamination by low numbers of bacteria, but a few wells (06N1, 06N6, and 07G3) exhibited severe or consistent bacterial contamination. One well (07C3) exhibited severe bacterial contamination only during the spring.

Bacterial species identified from wells during the spring include *Aeromonas caviae, Citrobacter freundii, Enterobacter agglomerans, Enterococcus avium, Enterococcus faecium, Escherichia coli, Hafnia alvei, Klebsiella oxytoca,* and *Klebsiella pneumoniae* (Table 33). These species are found in a wide variety of habitats. *Aeromonas caviae* is found in sewage and sewage contaminated water, but also occurs in fresh water and on fish (Buchanan and Gibbons 1975, Krieg and Holt 1984). *Citrobacter freundii* is a normal inhabitant in healthy people, and is also found in

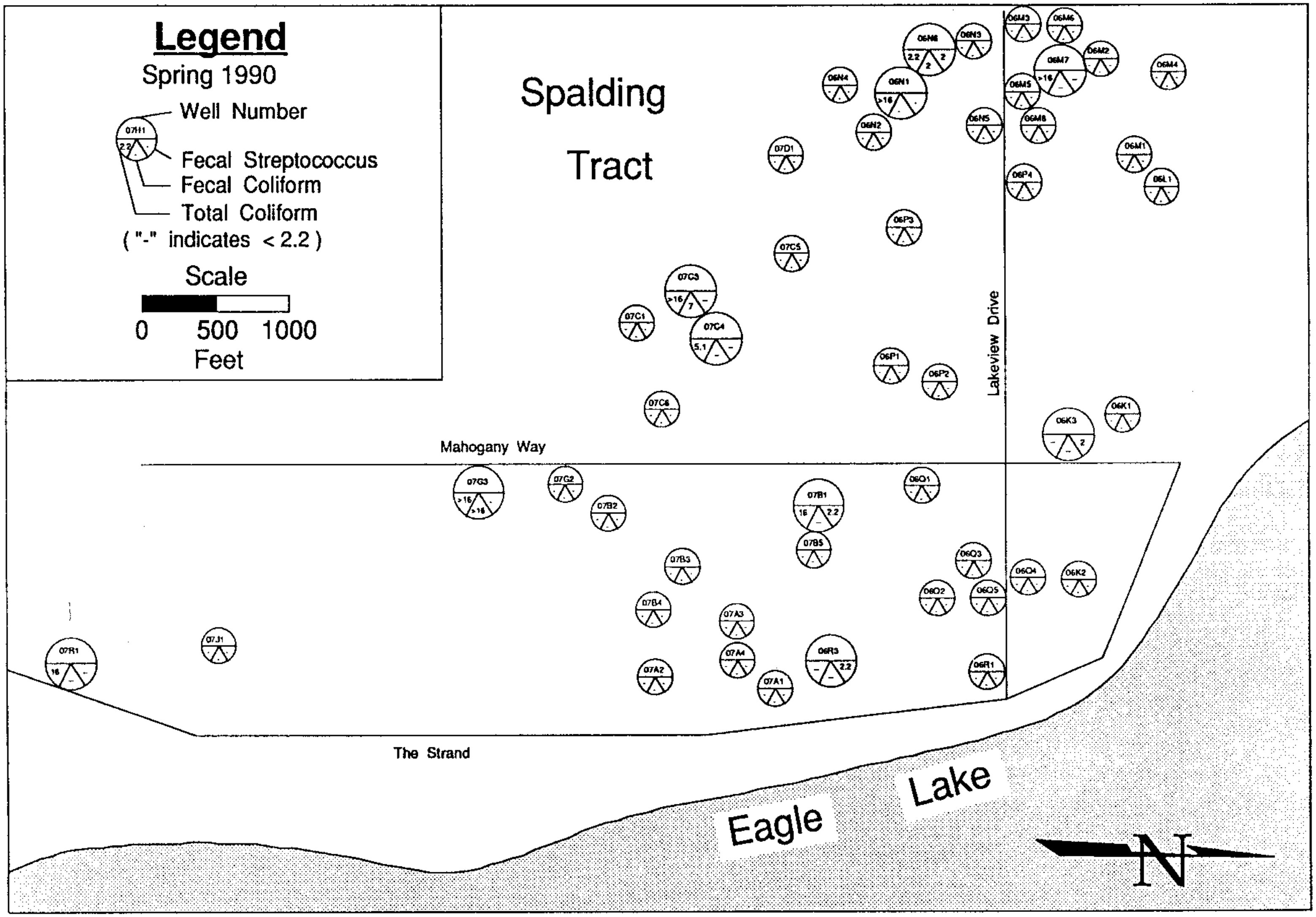


Figure 28. Bacteriological monitoring results from wells at Spalding Tract during spring 1990.

Table 33. Bacterial species isolated from well samples collected from Spalding Tract in May 1990

Well	Species	Well	Species
06K3	*Enterococcus faecium*	07C3	*Escherichia coli*
06M7	*Hafnia alvei*	07C4	*Hafnia alvei*
06N1	*Aeromonas caviae*		*Klebsiella oxytoca*
	Enterobacter agglomerans		*Klebsiella pneumonia*
	Citrobacter freundii		*Citrobacter freundii*
06N6	*Enterococcus faecium*	07C6	*Escherichia coli*
06R3	*Enterococcus faecium*		*Klebsiella oxytoca*
06Q2	*Aeromonas caviae*	07G2	*Hafnia alvei*
07B1	*Enterococcus avium*	07G3	*Escherichia coli*
07C1	*Citrobacter freundii*		*Citrobacter freundii*

other animals including mammals, birds, reptiles, and amphibians, as well as soil, water, and food. This bacterium is an opportunistic or secondary pathogen. Some strains of *Enterobacter agglomerans* occur in humans and other animals, while other strains occur in plants, flowers, seeds, vegetables, water, soil, and food stuffs. The *Enterococcus* bacteria are also referred to as *Streptococcus* bacteria. *Enterococcus avium*, which contains Lancefield's Group D and Q antigens, characteristically occurs in the feces of chickens, but occasionally is found from humans, dogs, and pigs. *Enterococcus faecium*, which contains Lancefield's Group D antigens, occurs in the feces of humans and other warm-blooded as well as cold-blooded animals, insects, plants, and non-sterile foods not related to fecal contamination. A subspecies, *E. faecium mobilis*, is found from grass silage. *Escherichia coli* is an opportunistic pathogen normally found in the lower part of the intestinal tract in healthy warm-blooded animals. *Hafnia alvei*, which is also an opportunistic pathogen, is found in the feces of humans and other animals including birds, sewage, soil, water, and dairy products. The *Klebsiella* bacteria are found in the intestinal tracts of humans and other animals. *K. oxytoca* is also found in plants and water. Other bacterial species could have been present but not isolated.

Discussion

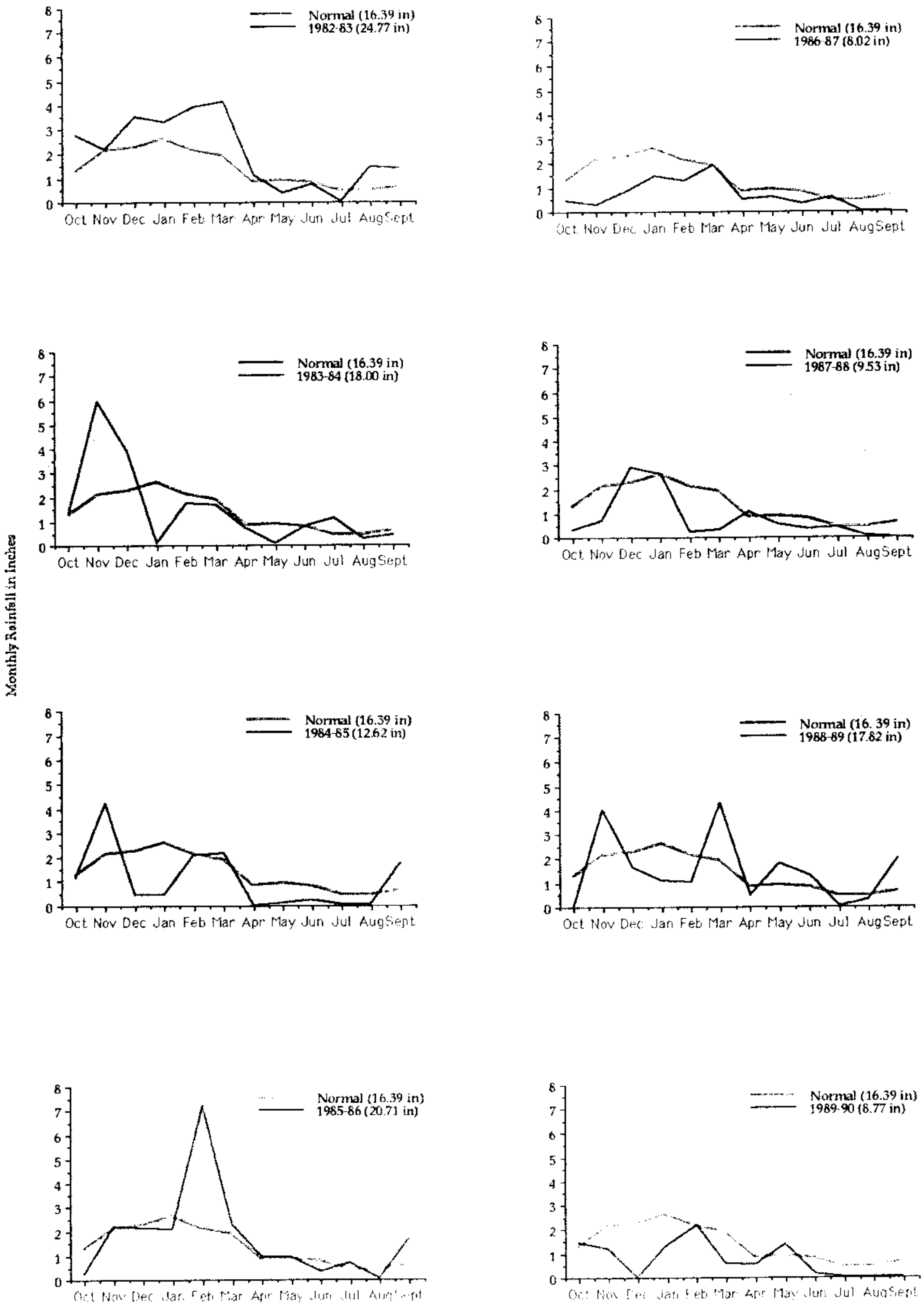
The dry winter conditions, which have persisted for the past several years over much of California, are probably responsible for the essentially flat water table and lack of ground water gradient. Ground water gradients in 1987-88 (Ruefer 1989) and

1989-90 were determined with data from water years with precipitation only about half of normal (Figure 29). The 1988-89 water year had above average precipitation due to exceptionally wet spring conditions, which would likely result in surface runoff of most of the precipitation rather than percolation into the ground.

The greater nitrate nitrogen concentrations during the spring at wells throughout the subdivision indicate a common source of most of the nitrate nitrogen. Average total nitrogen contributed by precipitation at Eagle Lake was determined from samples collected at a station in each of the three basins during selected storms during the 1982 and 1983 water years (DWR 1983). Average overall total nitrogen contributed by precipitation was 0.33 mg/L during the 1982 water year, and 0.30 mg/L during the 1983 water year. Total nitrogen concentrations during individual storms ranged from 0.03 to 2.43 mg/L. The latter value was not used in calculating the average total nitrogen concentration due to suspended matter contained in the sample. The average total nitrogen concentration from the station at Spalding Tract was 0.60 mg/L, with a range from 0.27 to 1.44, excluding the sample with suspended matter. Variations in nitrogen concentrations occur with different storms. The precipitation pattern prior to collection of samples during the spring of 1990 may have contributed sufficient nitrogen to elevate ground water nitrate nitrogen levels above those during the previous fall.

Extensive ground water contamination from septic tank leachfield systems is not evident from the chemical analyses data. Electrical conductivity levels and nitrate nitrogen and ortho-phosphate phosphorus concentrations were generally only slightly greater in downgradient wells. Chloride concentrations, however, were essentially uniform throughout the subdivision. Several wells, particularly some clustered in the northern part of the subdivision near the lake, exhibited levels and concentrations that were greater than other nearby upgradient and downgradient wells. The general slight increases in electrical conductivity levels and nitrate nitrogen and ortho-phosphate phosphorus concentrations in downgradient wells may be due to natural accumulation of minerals from soil as ground water flows through the subdivision. Dispersed input of minerals from leachfields could also be occurring, which is normal for properly operating septic system leachfields. Wells in the northern part of the subdivision near the lake may have exhibited higher

Figure 29. Rainfall comparisons between normal and water years since 1982-83.



Bacterial contamination was found in several wells for which no problems were indicated by the chemical analyses. Several wells, however, contained both elevated concentrations of at least one of the measured chemical constituents and bacteria. These wells (06N1, 06N4, 06P3, and 07G3) may have localized connection between leachfields and well water, though other mineral and bacterial sources could also be responsible.

None of the bacteria identified from the wells are restricted to humans. Other sources of these bacteria may exist within the subdivision. Coliform and streptococci bacteria should not be present in uncontaminated well water. Poor well seals may be responsible for some contamination by bacteria from the ground surface or shallow water (leachfield) sources. The occurrence of a wide variety of bacteria that can all have human fecal origin, however, suggests septic leachfield systems as the common source.

Placement of wells in relation to the location of the septic system leachfield on individual lots may be responsible for some of the contamination problems. Well 07G3, for example, is bordered to the west, or upgradient, by national forest with no waste disposal facilities, yet high bacterial contamination and elevated nitrate nitrogen and chloride concentrations were found from this well. This well and 06N1, which also had high bacterial contamination and elevated nitrate nitrogen and chloride concentrations, are reported to be downgradient from the septic system leachfields serving the lots on which they are located.

Well construction and surface seals may be a significant source of contamination problems. Well drillers logs indicate "natural earth" or cement seals to about 20 feet for most of the wells (Table 34). Natural earth is not an effective seal to prevent the transport to the well of contaminants from the ground surface or shallow water, such as leachfield effluent. Cement seals may shrink while curing, thereby pulling away from the bore hole and creating a pathway for surface or shallow water contamination.

Wells at Spalding Tract have most often been installed in covered concrete block lined pits and above ground well houses, or employ pitless adapters. Well 06N4,

Table 34. Characteristics of wells selected for monitoring at Spalding Tract.

Well	Date Constructed	Well Depth (feet)	Casing Depth (feet)	Perforation Depth (feet)	Seal Depth (feet)	Seal Material
06K1	1966	55	29	-	-	Clay Seal
06K2	1977	60	40	-	40	Natural Earth
06K3	1976	59	59	34-59	-	-
06L1	1974	62	26	-	-	Cement
06M1	1982	73	50	50-70	32	Cement
06M2	1983	58	-	8-50	-	Bentonite
06M3	1978	62	42	-	40	Natural Earth
06M4	1986	68	68	48-68	50	Cement
06M5	1984	57	57	37-57	30	Bentonite
06M6	1984	58	58	38-58	29	Bentonite
06M7	1984	59	59	39-59	20	Bentonite
06M8	1988	68	68	58-68	20	Bentonite
06N1	1986	68	68	8-68	20	Cement
06N2	1988	60	60	50-60	20	Bentonite
06N3	1979	62	20	-	20	Natural Earth
06N4	1976	75	40	-	20	-
06N5	1979	63	40	-	40	Natural Earth
06N6	1980	65	60	50-60	60	Natural Earth
06P1	1987	68	68	48-68	21	Cement
06P2	1986	68	68	48-68	14	Cement
06P3	1988	60	60	50-60	20	Bentonite
06P4	1981	60	60	41-60	18	Cement
06Q1	1966	58	16	-	-	Clay Seal
06Q2	1986	58	58	38-58	24	Cement
06Q3	1981	55	20	-	none	-
06Q4	1986	68	68	8-68	45	Cement From 35 to 45
06Q5	1976	50	30	10-30	20	Cement
06R1	1979	52	45	25-45	-	Natural Earth
06R2	1980	55	30	-	-	Natural Earth
06R3	1982	59	59	39-59	30	Annular neat cmt., bentonite
07A1	1986	68	68	48-68	40	Cement
07A2	1979	50	26	-	26	Natural Earth
07A3	1973	42	42	26-42	6	-
07A4	1971	43	43	28-43	7	-
07B1	1979	60	20	-	-	Natural Earth
07B2	1986	68	68	8-68	20	Cement
07B3	1980	60	50	30-50	-	Natural Earth
07B4	1986	58	58	38-58	22	Cement
07B5	1978	56	34	-	-	-
07C1	1987	68	68	48-68	21	Cement
07C2	1976	53	53	33-53	20	Cement
07C3	1975	63	20	-	20	Cement
07C4	1980	55	23	-	-	Natural Earth
07C5	1987	68	68	48-68	20	Cement
07C6	1983	68	68	20-60	19	Bentonite
07D1	1976	65	20	-	20	Cement
07G1	1979	60	55	35-55	30	Natural Earth
07G2	1979	63	60	40-60	-	Natural Earth
07G3	1986	68	68	28-68	21	Cement
07H1	1986	48	48	28-48	21	Cement
07J1	1976	55	20	-	20	Cement
07R1	1975	52	20	-	20	Cement Grout

which contained high numbers of total and fecal coliform bacteria during the fall of 1989, is located in a concrete block lined pit that is about 8 feet deep, with the well casing extending above the floor by about 1 foot. While running the tap outside the well house to obtain samples, water was noted to pour through holes in the concrete blocks and cement grout of the pit. An old high water line was found 2 feet from the floor of the structure, indicating that the well casing has been inundated by up to 1 foot of water in the past. The top of the well casing is fitted with a metal cap with several large holes through which power wires and support cables for the pump are run, but which also would readily allow water to enter. Bacterial contamination in this well may be the result of surface runoff flowing into the pit, overtopping the well casing, and flowing into the well.

Pitless adapters are used to prevent water line freezing during the winter. Plumbing is routed beneath the surface of the ground, with only the end of the well casing at ground level. A metal cap, sometimes with a seal, covers the end of the casing. Most pitless adapter caps have a side hole about 1 inch in diameter for routing of electrical wires. Most well casings employing pitless adapters extend above the ground surface several inches. However, the pitless adapter cap is below ground level at some wells, such as 06M6, 06M7, and 07B2, which could allow surface runoff, soil, and contamination to enter the wells.

Other activities that allow contaminants to enter the well or water system could also be responsible for bacterial contamination. An additional faucet was added to the water system served by well 06N6 a short time prior to sampling in the fall of 1989. The water line was added adjacent to a pen containing several very active large dogs. The pipe was noted to contain some dirt, but was not cleaned prior to completing the installation. Detected contaminants could have resulted from the newly added water line. Bacterial contamination was found in September and October at high levels, but had become reduced to only 2 total coliform colonies per 100 mL by December 1989. The owner reported that subsequent testing failed to produce any evidence of bacterial contamination. However, both total and fecal coliform and fecal streptococcus bacteria were detected at low concentrations from samples collected during the spring of 1990. The loosely capped top of the well casing is about 10 inches below the ground surface in a metal 55 gallon drum in the front

lawn about 15 feet from the dog pen. This arrangement is also a possible source for contamination.

The shallow soils in the subdivision, which are underlain by clay and basalt or only basalt in some areas (Figure 30), may provide inadequate adsorption of minerals and filtration of bacteria and other microorganisms from leachfield effluent. Nitrate and chloride are not readily adsorbed by soil but move freely with water, which makes these parameters good indicators of septic contamination. Bacteria can travel great distances through porous soil, with reports common for bacterial migration of 100 feet or more (Perkins 1984). Viruses appear to be even more mobile, with reports of migration up to 1,300 feet from the source. The clay layer may present a barrier for rapid percolation to the water-bearing highly fractured basalt of effluent containing elevated concentrations of minerals and potentially pathogenic microorganisms. In areas lacking a clay layer or where the clay layer is perforated by inadequately sealed well casings, however, ground water in the basalt may be easily contaminated by percolating effluent from the shallow soil layer. Effluent may also flow horizontally along the clay layer before percolating to the basalt when the clay layer disappears. Effluent that has percolated to the basalt can be transported by ground water flow to other areas beneath any clay layers. Many of the wells with elevated nitrate nitrogen and chloride concentrations and bacterial contamination are in or near areas with shallow soil underlain by basalt but no clay layer.

Restrictive layers between the water table and leachfield provide local zones of saturation where anaerobic conditions may develop to promote denitrification (Bauman and Schafer 1984). Denitrification is enhanced with longer residence times. The clay layer between the soil and water-bearing basalt in much of Spalding Tract may allow development of anaerobic conditions. The lack of a ground water gradient would increase the residence time of effluent at the clay boundary. Both conditions may be important in limiting nitrate contributions to ground water from effluent through denitrification.

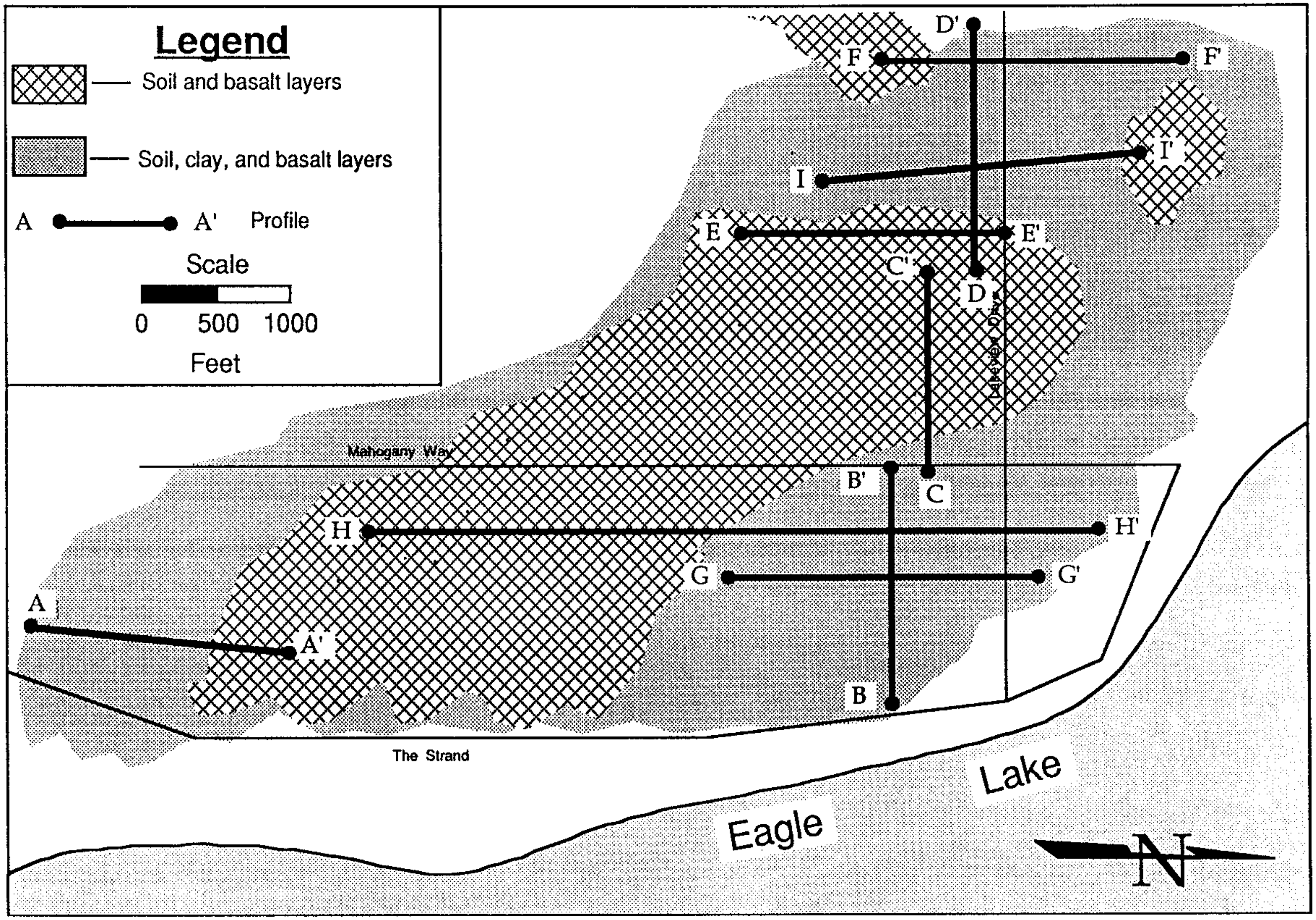


Figure 30. Generalized substrate profiles in Spalding Tract (data from RWQCB 1981b).

CONCLUSIONS

Chemical analyses and bacteriological data have been collected from wells at Spalding Tract by various agencies and individuals since 1982. Additional data have been collected from well logs and trenches throughout the subdivision to determine whether soils meet the requirements in the Water Quality Control Plan for septic system leachfields. Amendments to the Water Quality Control Plan were adopted September 14, 1984 based on analyses of available data. The amendments require no discharge of nutrients from sewage to ground water in the Eagle Lake basin after September 14, 1989.

Data collected prior to adoption of the amendments were used to show that chemicals associated with leachfield effluent increased in downgradient wells. Ground water was assumed to move toward Eagle Lake based on hydrological expectation and ground water elevations reported from well logs. Mean concentrations of nitrate nitrogen, ortho-phosphate phosphorus, and chloride combined from three wells near the shore of Eagle Lake, which were assumed to be downgradient, were compared with concentrations from one well near the western boundary of the subdivision that was considered upgradient. The mean concentrations of these parameters in the downgradient wells were significantly greater than concentrations from the upgradient well. While multiple sampling sites are normally desired to eliminate bias due to uncharacteristic conditions from a single site, use of mean downgradient well concentrations in this analysis resulted in the indication of high concentrations of the various parameters at all three downgradient wells.

Comparisons of concentrations from individual downgradient wells with the upgradient well indicate that only one of the three downgradient wells had significantly different concentrations of nitrate nitrogen, ortho-phosphate phosphorus, and chloride. Concentrations of these parameters in the other two downgradient wells were essentially the same as in the upgradient well.

Subsequent data collected since 1987 from wells throughout the subdivision generally indicate only slight increases in nitrate nitrogen and ortho-phosphate

phosphorus concentrations in the downgradient direction, which is normal for ground water movement through soil, but which may also indicate diffuse contributions from normally operating septic system leachfields. Chloride, however, exhibited generally uniform concentrations throughout the subdivision. Elevated chloride concentrations would be expected to occur in conjunction with elevated nitrate nitrogen concentrations if leachfield contributions were a significant source. Leachfield effluent may not have been detected at significant concentrations from well samples due to limited dispersal in the ground water. The major portion of well water is pumped from the deeper portions of the aquifer, resulting in little input from aquifer surface contaminants.

Some wells scattered throughout the subdivision were found with elevated concentrations of at least some of the monitored parameters. The increases in concentrations of nitrate nitrogen, ortho-phosphate phosphorus, and chloride were not substantial in relation to increases that have been found in other areas affected by septic system contamination of ground water. Increases at some wells, however, were substantial relative to the concentrations found at other wells in the subdivision. Sources for the elevated parameters may include localized mineral deposits or septic effluent contamination. Widespread contamination, however, is not indicated by the chemical data. Concentrations of the monitored parameters are well below levels that are considered to be health concerns.

Bacterial contamination has been found in wells from throughout the subdivision (Figure 31). Thirty-eight wells have been identified with bacterial contamination at least on one occasion from the 88 apparently different wells sampled since 1982, excluding those sampled by Ruefer (1989). Wells referenced by ownership were assumed to represent different wells in the various studies if listed ownership was different. Ownership may have changed, however, resulting in the appearance of a greater number of wells being sampled than actually were sampled. Data from Ruefer (1989) were not included in the number of wells sampled or exhibiting contamination because neither ownership nor Department of Water Resources well numbers were listed to provide any cross reference between studies.

Most of the wells were sampled only once or twice. Data from wells sampled more

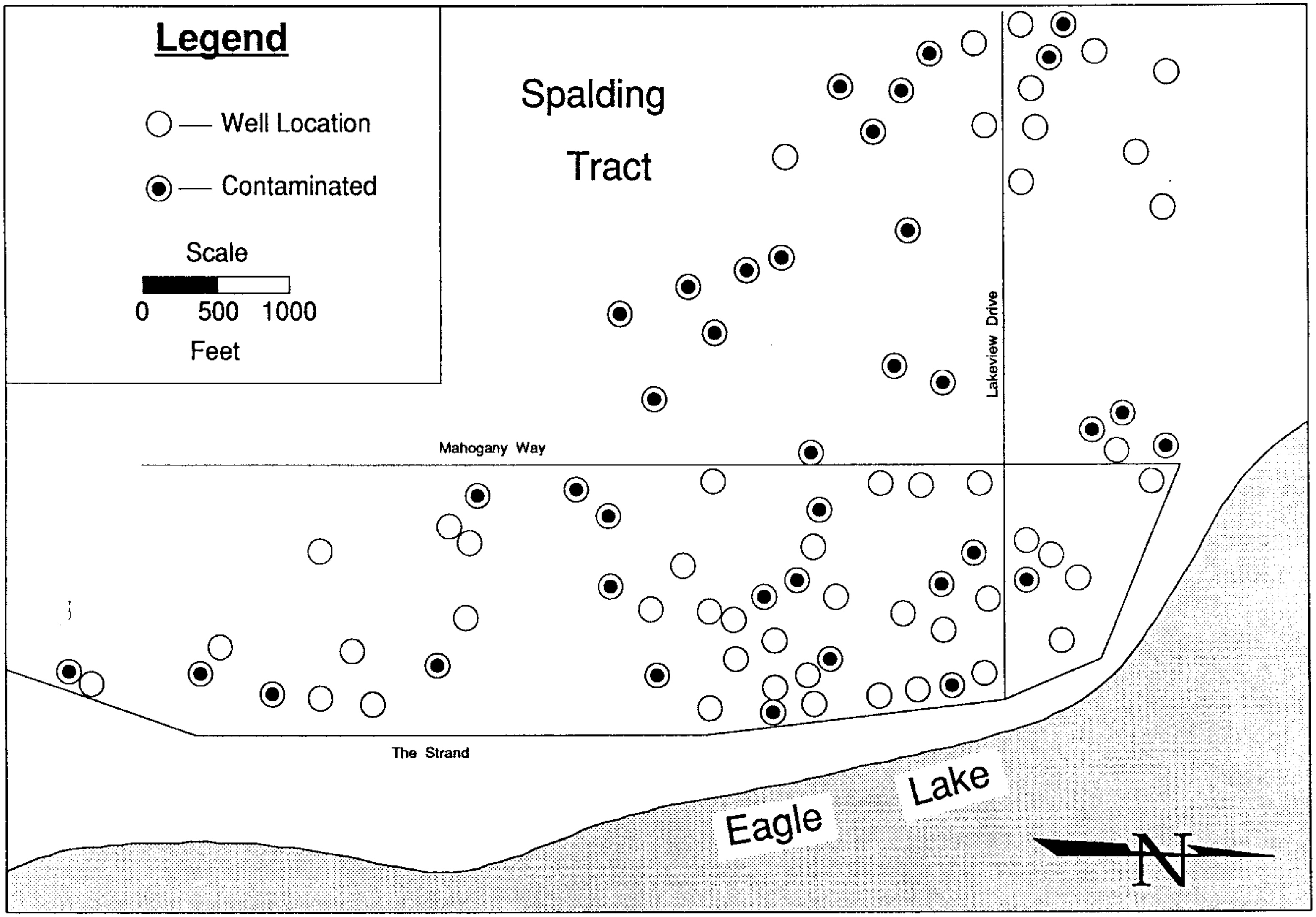


Figure 31. Wells monitored for bacterial contamination at Spalding Tract.

frequently indicate that bacterial contamination commonly occurs sporadically. At least some of the 50 wells that had not exhibited contamination from limited sampling could at other times have contained bacterial contamination. Low levels of bacterial contamination identified from wells from a single sample are inadequate for evaluating sanitary significance, and require confirmation with a series of samples collected over a protracted period. However, any bacterial contamination in wells is of concern.

Coliform bacteria, which are normal inhabitants of humans, are considered indicators of contamination by human or animal feces. Though coliform bacteria may not produce disease in healthy individuals, they indicate the potential presence of bacterial species capable of causing disease.

Drinking water regulations do not apply to private individual water systems. Criteria for public water systems have been established as less than 2.2 MPN from the multiple-tube fermentation technique and no more than 1 coliform colony per 100 mL of sample for the membrane filter technique. Thirty-seven of the 38 wells at Spalding Tract exhibiting bacterial contamination since 1982 exceeded these criteria, though most were not confirmed with additional samples.

The types of bacteria found in wells have been used to indicate probable sources of contamination. However, many of the bacteria have many different sources, which in addition to contamination from septic effluent include soil, water, plants, insects, and a variety of warm-blooded animals such as humans, birds, cows, horses, and dogs.

Possible sources of bacterial contamination have been identified for some wells. Inadequate well casing seals may allow infiltration to ground water of surface or shallow water (effluent) contaminants. Poor fitting casing caps can allow infiltration into the well casing of surface contaminants. Inundation of well casing caps due to placement below ground level or in well houses subject to water infiltration allow surface contaminants to enter wells. Possible sources of bacterial contamination, however, also include septic effluent. Wells have been identified with septic systems located a short distance away as the likely source of

contamination. Elevated chemical constituents plus bacterial contamination at some wells provide strong evidence for septic contamination, though other causes may still be possible.

Waste disposal standards at Spalding Tract follow guidelines in the Uniform Plumbing Code developed for typical soils. Soils at Spalding Tract may have different adsorption capacities than those from which the guidelines were developed. Site specific analyses at Spalding Tract to determine soil adsorption capacity has not been conducted.

Soils in large portions of the subdivision do not meet the Water Quality Control Plan standards for underground waste disposal systems. Silty sands and sandy clays, which form the shallow upper soil profile, average 5 to 7 feet in depth in most of the subdivision. Clay that varies in thickness from 0 to 30 feet underlies the soil layer. The clay layer may be a barrier to rapid percolation of leachfield effluent to the ground water, except where non-existent, thin, or perforated by an inadequately sealed well casing. Highly fractured basalt, occurring at the surface in some areas, lies beneath the soil or soil and clay layers. The fractured basalt readily transmits water and is the source of water for wells in Spalding Tract. Soils of sufficient composition and depth are not present that are generally deemed necessary to adequately adsorb minerals and nutrients or filter microbial organisms from percolating leachfield effluent. In areas lacking a clay layer, rapid percolation of leachfield effluent to the basalt may be responsible for increased mineral concentrations and bacterial contamination of the ground water. Horizontal dispersion of effluent at the surface of the clay layer may be responsible for contamination in downgradient areas where the clay layer disappears to no longer separate the basalt from the shallow surface soil. Denitrification under anaerobic conditions at the clay layer surface could reduce the concentration of nitrate in leachfield effluent.

Increases in minerals as ground water moves beneath the subdivision are expected from properly operating septic systems, though the observed increases may also be due to dissolution of natural soil minerals. Some areas at Spalding Tract, though, may be unsuitable for septic systems. Thin soils, clay, and shallow basalt may affect

proper operation of subsurface waste disposal systems in many parts of Spalding Tract. Some current septic systems may be located in unsuitable areas, which may be contributing to some of the increases in chemical constituents in the ground water and bacterial contamination. Localized increases of minerals in ground water may indicate saturation of soil adsorption capacities in areas with inadequate soils. However, no surface indications of malfunctioning underground septic systems are apparent at Spalding Tract. Site specific evaluation for determination of suitability for underground septic systems is needed due to the highly variable nature of soil throughout the subdivision.

Water samples obtained from wells are pumped from near the bottom of the well casings. The average depth of wells sampled in Spalding Tract is 60 feet, while the ground water table varies from about 12 feet near Eagle Lake to 48 feet further inland. Leachate normally does not mix into the aquifer, but remains near the surface of the ground water. Insufficient vertical mixing into the aquifer and dilution with water pumped from near the bottom of wells may prevent identification of high concentrations of leachate chemicals and bacteria that may be percolating to the ground water.

Drought, which has affected much of California during the past several years, could affect transport of effluent through soils at Spalding Tract. Lack of percolating water could allow minerals from leachfield effluent to concentrate in the upper soil layer, with little movement to the water-bearing basalt. Essentially flat ground water levels during the 1987-88 (Ruefer 1989) and 1989-90 water years may have been due to precipitation that was only about half of normal. Lack of a ground water gradient could result in leachfield effluent dispersion by local diffusion or transport with ground water to nearby pumping wells rather than downgradient dispersion. Localized dispersion could be responsible for the substantially elevated minerals in some scattered wells while not contributing to general downgradient increases.

Ground water quality monitoring data collected since 1982 from Spalding Tract do not conclusively indicate septic system leachfield effluent as the source of contamination in water wells. Increases in chemical constituents and bacterial contamination in water from wells at Spalding Tract could be from leachfield

effluent, but other potential sources may also be present. Consistent high concentrations of monitored chemical parameters and contamination by bacteria associated with effluent in some wells provide strong, but still circumstantial, evidence for leachfield effluent contamination. The significant number of wells exhibiting bacteria poses serious concern for contamination from leachfield effluent, but other sources of contamination into poorly constructed or maintained wells may also be responsible. Shallow soils have been subjectively determined to be inadequate in many parts of the subdivision for underground waste disposal systems, but adsorption capacity for treating effluent has not been determined. Clay, lying beneath the thin soil layer in much of the subdivision, may prevent the rapid percolation and detection in the water-bearing basalt of effluent that could be very concentrated. Significant chemical and bacterial contamination associated with effluent may not have been detected in most wells, though possibly present, due to inadequate vertical mixing of effluent into the ground water and dilution with water pumped from deep within the aquifer. Lack of information about underground transport of leachfield effluent at Spalding Tract prevents definitive connection between septic systems and ground water contamination.

Summation

- Pervasive contamination of ground water from septic system leachfield effluent is not indicated by monitoring data collected since 1982.
- Minor downgradient increases in nitrate nitrogen, ortho-phosphate phosphorus, and chloride concentrations may be due to natural dissolution of minerals from soils or diffuse contributions from normally operating septic systems.
- Concentrations of monitored chemical parameters are well below levels that are considered to be health concerns.
- Bacterial contamination in wells is rather widespread, indicating a serious potential for health problems.
- Species of bacteria found may be associated with soil, water, plants, insects, or a variety of warm-blooded animals including, birds, cows, horses, and dogs, but all are associated with human wastes.
- Elevated chemical constituents plus bacterial contamination at some wells provide strong evidence for localized septic contamination.

- Well construction and inadequate surface seals may be a significant source of contamination in many wells at Spalding Tract.
- Chemical and bacterial data provide circumstantial but not conclusive evidence for contamination of ground water by septic system leachfields.
- Lack of information about underground transport of leachfield effluent at Spalding Tract prevents definitive connection between septic systems and ground water contamination.
- Insufficient vertical mixing of leachfield effluent into the ground water may prevent identification of pervasive contamination.
- Capacity of soil in Spalding Tract to adsorb septic system wastes has not been determined.
- Clay, lying between the shallow surface soil and water-bearing basalt in many areas, may be a barrier to percolation of leachfield effluent, but data are not available to determine the role of the clay layer.

RECOMMENDATIONS

Ground water data collected from Spalding Tract since 1982 have provided circumstantial but not definitive indications of contamination by septic system leachfields. Additional data are required to better define the relationship between leachfield effluent and possible ground water contamination.

Close proximity of wells to septic system leachfields could allow rapid transport of effluent with minimal adsorption and filtration of effluent. Some contamination may be due to lack of adequate spacing between septic systems and wells on the small lots at Spalding Tract.

- *All wells and septic system leachfields should be mapped to determine inappropriately situated systems and to avoid siting future wells in close proximity to septic systems.*

At least some wells and septic systems were poorly installed or have been poorly maintained. Some old hand dug wells or wells with badly corroded casings apparently exist at Spalding Tract. Such wells may allow ready infiltration of contaminants to the ground water, resulting in contamination of drinking water for surrounding residents. Other wells are poorly sealed to prevent infiltration of contaminants along the well casing. Some septic systems apparently consist of little more than perforated 55 gallon metal drums buried under ground. Other septic tank and leachfield systems may be poorly maintained and not operating effectively.

- *Both wells and septic systems should be inspected to assure proper operation and adherence to minimum standards.*

Ground water elevations may be close to the ground surface in some areas of the subdivision, particularly near the lake. Inadequate treatment of effluent would occur in areas with saturated soil near the surface.

- *Accurate contour maps of ground surface elevations and ground water elevations are required to assess suitability for siting underground sewage disposal systems.*

Bacterial contamination is not consistently found in wells at Spalding Tract. Many

more than the 38 wells that have been detected with bacteria may also be subject to contamination.

- *Monthly monitoring of wells by property owners is recommended to detect bacterial contamination and the necessity of water treatment before consumption.*

Subjective evaluation indicates that the thin soil layer at Spalding Tract may not be sufficient to adequately treat septic system leachfield effluent. Continued use could overload the adsorption capacity of these soils, resulting in inadequate treatment of effluent and contamination of ground water.

- *The soil adsorption capacity should be objectively analyzed.*

The clay layer, which has not been adequately characterized, may present a barrier to the percolation of septic system effluent. Percolating effluent may travel horizontally upon encountering the clay surface. Contamination of the water-bearing basalt can occur where the clay disappears or is penetrated by inadequately sealed well casings. High concentrations of minerals and nutrients in the effluent at the soil-clay interface could be transported without detection to Eagle Lake.

- *The structural composition and extent of the clay layer should be defined to determine effects on percolating effluent and surface water.*
- *Shallow monitoring wells should be constructed for extraction and chemical and microbiological analyses of water samples at the soil-clay interface to determine the effect of the clay layer on effluent percolation.*

Lack of vertical mixing into ground water by leachfield effluent may preclude detection of elevated chemical parameters or bacteria in samples collected from drinking water supply wells. Well pumps extract most water from the deeper portions of the aquifer, with relatively little input of water from upper portions, resulting in dilution of contaminants. Such undetected contaminants may travel with ground water to downgradient portions of the subdivision or to Eagle Lake.

- *Shallow wells should be constructed for collection of water samples near the surface of the water table to determine the potential and*

extent of septic system contamination of ground water.

Dye had been used in an attempt to provide direct evidence of leachfield effluent percolation to ground water in the Stones-Bengard subdivision. The dye, however, could not be detected from well water. Other tracers, such as antibodies or isotopes, may be appropriate for providing evidence of direct connection between leachfields and water wells.

- *The use of tracers should be investigated to provide definitive evidence of the connection between leachfield effluent and ground water.*

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